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Description and
Operating Manual

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Group Delay and Attenuation Measuring Set

LD-30

in the frequency range 200 Hz to 20 kHz

QUALITY ASSURANCE
STANDARDS, CALIBRATION, AND
MAINTENANCE LAB.

GROUP DELAY AND ATTENUATION MEASURING SET LD-30

in the frequency range 200 Hz to 20 kHz

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INTRODUCTION

The trend of data transmissions on telephone circuits is always towards higher and higher transmission speeds (presently to 9600 bits/s). In order to eliminate errors occuring during transmission, the group delay and the attenuation frequency distortion must be measured over the frequency range 300 Hz to 3.4 kHz. The ensuing variations with frequency, especially for fixed installed circuits, (rented circuits) should be equalized according to the CCITT Recommendation M.102.

The Group Delay and Attenuation Measuring Set LD-30 is suitable for measuring the distortions, and it fulfills in all points the CCITT-Recommendation O.81. Furthermore, the LD-30 offers considerably more advantages.

In combination with our Attenuation and Delay Equalizer DLZ-4 rapid and optimum circuit equalization can be effected.

The Measuring Set LD-30 embodies an application of the carrier sampling method [1] applied for the past 15 years in our Group Delay and Attenuation Measuring Setups and considerably simplifies end-to-end measurements. This method is an extension of the Nyquist principle: two carrier frequencies, both from one generator, are alternately sampled at a 4.166 Hz rate, and each is continuously amplitude modulated by the 41.66 Hz frequency known as the "split" frequency. One of the two carrier frequencies is varied within the frequency range of interest (measuring carrier), while the second is held at a fixed frequency (reference carrier). The reference carrier frequency can be tuned to an optional frequency within the transmission range of the test specimen to be measured. As an identifying signal for the reference carrier, a frequency of 166.66 Hz is used for additional amplitude modulation on the reference carrier during the last fifth of the interval taken for sending the reference carrier. If the measuring signal sent via the test specimen is received with group delay distortion values which are different for each of the carrier frequencies, then there is exhibited a shift in time for the envelope of the signal at the output of the test specimen. Moreover, the difference in attenuation causes a surge in the carrier amplitude. Within the receiver at the far end, the shift in time or else the amplitude surge is evaluated and indicated accordingly.

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1) DBP 1025072 and 1050441

The procedure permits swept frequency measurements over a prescribed frequency range as well as point-by-points measurements. The measured results can be read at the meter or plotted on an X-Y recorder. The LD-30 is easily used for end-to-end measurements. Generator and Receiver are contained in one cabinet. The single cabinet method of construction provides the advantages of saving the doubling of sub-assemblies (e.g. frequency readouts, power supplies), eliminating cable connections which previously were necessary but have been replaced with internal connections, better possibilities for calibrating a pen recorder, lower weight, smaller dimensions and an economical price. The LD-30 is designed to provide simple operation and easy servicability.

It is possible to select measuring frequencies in the ranges of 200 Hz to 4 kHz (especially useful for measurements on telephone circuits) and 200 Hz to 20 kHz. And the reference frequency is adjustable in 100 Hz increments over the complete frequency range.

Send and receive frequencies after changing over can be read on a four digit 7 segment incandescent readout. The measuring frequency is sweepable with 5 sweep rates each of which can be single shot or continuous whereby the sweep limits are set-up digitally.

The send and receive level ranges are - 50 dBm to + 10 dBm; moreover without needing a change of receiver sensitivity.

For the output or input impedance value of 600 Ω a second value can be additionally chosen. The test results for $\Delta\tau g$, Δa and input level can be indicated on an analog meter when push buttons are actuated in the desired order:
A self-contained speech facility enables conversations without requiring an additional voice channel between the ends when end-to-end measurements are made.

Additional possibilities offered by the LD-30 Measuring Set are:
Retransmission of measured results, remote control of the Generator over the measuring path, application as AF level and swept frequency measuring setup, dial tone blocking and d.c. loop-holding circuit.

All the advantages mentioned plus the easy operational capability add up to make the Group Delay and Attenuation Measuring Set LD-30 a true in-service measuring set.

1. SPECIFICATIONS

1.1. Rated ranges of use

The rated ranges of use describe the various service conditions (in optional combinations) which are valid for the given limits of accuracy.
Deviations from nominal operating conditions are specially noted.

A.C. line voltage	110/117/127/220/227/235 V, - 15 % to + 10 %
A.C. line frequency	45 to 66 Hz
Ambient temperature	+ 5 °C to + 50 °C
Warm up time:	≧ 10 min.
for receive level of point 1.2.	≧ 1 hour

Generator

Carrier oscillation Measuring frequency MF and Reference frequency VF	200 Hz to 20 kHz
Output level	- 50 dBm to + 11 dBm
Termination impedance balanced, floating	600 Ω

Receiver

Carrier oscillation Measuring frequency MF	200 Hz to 20 kHz
Reference frequency VF	400 Hz to 20 kHz
Input level of carrier oscillation at the measuring and the reference frequencies	- 40 dBm to + 10 dBm
Output impedance of source	600 Ω
Level difference of the carrier oscillation at the measuring and the reference frequencies	
for group delay distortion measurements	- 30 dB to + 30 dB
for attenuation frequency distortion measurements	- 30 dB to + 30 dB
Group delay difference between measuring and reference frequencies	- 10 ms to + 15 ms

1.2. Complete Measuring Set LD-30

Range of application

Frequency range	200 Hz to 20 kHz
Level range	- 50 dBm to + 10 dBm
Measurable group delay distortion	± 10 µs to + 15/- 10 ms
Measurable attenuation frequency distortion	± 0.05 dB to ± 50 dB

Accuracy limits for group delay distortion measurements

Zero point and variation with frequency (for negligible attenuation frequency distortion)

in frequency range:	1 kHz to 20 kHz	5 µs
	600 Hz to 1 kHz	10 µs
	400 Hz to 600 Hz	30 µs
	200 Hz to 400 Hz	100 µs

These errors can be determined by means of a direct connection between Generator and Receiver and accordingly can be included as corrections of the measured results.
See "Technical Instructions", Section 3.1.

Accuracy of readings

In temperature range + 15 °C to + 35 °C	± 2 % f.s.d.
At rated range of use	± 4 % f.s.d.

Additional errors due to simultaneous presence of attenuation frequency distortion:

to ± 10 dB	± 3 µs
± 20 dB	± 5 µs
± 30 dB	± 10 µs

Accurcy limits for attenuation frequency distortion measurement

Variation with frequency . . . . . ± 0.15 dB

These errors can be determined by means of a direct connection between Generator and Receiver and accordingly can be included as correction of the measured results.
See "Technical Instructions", Section 3.2.

Accuracy of readings . . . . . ± 3 % f.s.d. ± 0.05 dB

Accuracy limits of the levels

Send level

In temperature range + 15 °C to + 35 °C	
at frequency point 1.8 kHz (CCITT Recommendation O.81)	± 0.25 dB
for optional frequencies	± 0.3 dB
Under conditions of rated range of use	
at frequency point 1.8 kHz (CCITT Recommendation O.81)	± 0.3 dB
for optional frequencies	± 0.35 dB

Receive level

In temperature range + 15 °C to + 35 °C and level range - 20 dBm to + 10 dBm	
at frequency point 1.8 kHz (CCITT Recommendation O.81)	± 0.25 dB
for optional frequencies	± 0.35 dB

Under conditions of rated range of use
at frequency point 1.8 kHz (CCITT Recommendation O.81) . . . ± 1 dB
for optional frequencies . . . . . ± 1.1 dB

Frequency

Counter display resolution . . . . . 10 Hz
with depressed push button, resolution . . . . . 1 Hz

Accuracy limits of the frequency readings (counter readout)

Readout accuracy of send frequency

With installed crystal controlled time base
BN 691/13 (see paragraph 2.9.3.) . . . . . ± 0.001 % ± 1 digit

Without crystal controlled time base
In temperature range + 15 °C to + 35 °C . . . . . ± 0.5 % ± 1 digit
Under conditions of rated range of use . . . . . ± 1 % ± 1 digit

Readout accuracy of the receive frequency

As in section 1.2., "Readout Accuracy of Send Frequency",
however, ... ± 1 Hz

1.3. Generator specifications

Send signal according to CCITT Recommendation O.81 see Fig. 4-2

Frequency

Measuring frequency

Manually adjustable in two ranges . . . . . 200 Hz to 4 kHz
and . . . . . 200 Hz to 20 kHz

or

sweepable between two optional
selectable frequency limits in range . . . . . 200 Hz to 20 kHz

Setting of frequency limits in
decadical increments of . . . . . 100 Hz
additional constant detuning possibility . . . . . ± 150 Hz

Push buttons permit checking the frequency limits
with the in-built frequency counter used for
the measuring frequency readout.

Sweep rates . . . . . 10, 20, 50, 100, 200 $\frac{Hz}{s}$ ± 15 %

Sweep curve . . . . . single shot, starting
at any freq. limit,
or continuous, triangular shaped

Reference frequency

Optionally selectable in range . . . . . 400 Hz to 20 kHz

Setting of reference frequency
decadical increments of . . . . . 100 Hz
additional continuous detuning possibility . . . . . ± 150 Hz

Push buttons permit checking the reference frequency with the in-built frequency counter used for the measuring frequency readout.

Accuracy limits of the frequency settings are the same as those under section 1.2., "Readout Accuracy of Send Frequency".

Modulation

Sinusoidal modulation

Modulation frequency . . . . . 41.66 Hz
Modulation depth . . . . . 0.4 ± 0.02
Modulation distortion factor . . . . . ≦ 1 %

"Rectangular" wave identifying modulation

Modulation frequency . . . . . 166.66 Hz
Modulation depth . . . . . 0.2 ± 0.05
Time constant of "rounding off" the identifying modulation . . . . . 0.43 ms

Phase position and send time of identifying modulation can be extracted from Fig. 4-2.

Carrier frequency change-over

Change-over frequency . . . . . 4.166 Hz

Deviation of the change-over time point from minimum of the envelope curve of the send signal . . . . . ≦ 0.2 ms
Change-over time . . . . . ≦ 0.1 ms

Accuracy limits of all modulation frequencies in temperature range + 15 °C to + 35 °C . . . . . 0.5 %
Under conditions of rated range of use . . . . . 1 %

Send level

Settings

Setting range . . . . . - 51 dBm to + 11 dBm
Setting increments of . . . . . 5 dB
and continuous according to the scale of the calibrated potentiometer . . . . . - 6 dB to + 1 dB

Blanking the send level is possible by means of the push button

To be observed: The level calibration is referred to the unmodulated carrier signal. The r.m.s. value of the modulated send signal is higher by 0.33 dB.

Spectral purity

Total harmonic ratio of the carrier . . . . . ≧ 46 dB
Attenuation of non-harmonic impairment signals . . . . . ≧ 60 dB

Accuracy limits of the Generator

(contribution to the accuracy limits according to Section 1.2.)

Group delay distortion

Zero point and variation with frequency

in frequency range: 600 Hz to 20 kHz . . . . . ≦ 1 µs
400 Hz to 600 Hz . . . . . ≦ 3 µs
200 Hz to 400 Hz . . . . . ≦ 10 µs

Attenuation frequency distortion

Variation with frequency . . . . . ≦ ± 0.05 dB

Level

(compare with Section 1.2., "Accuracy Limits of the Send Level")

In temperature range + 15 °C to + 35 °C
at frequency point 1.8 kHz (CCITT Recommendation O.81) . . . ± 0.25 dB
for optional frequencies . . . . . ± 0.3 dB

Under conditions of rated range of use
at frequency point 1.8 kHz (CCITT Recommendation 0.81) . . . ± 0.3 dB
for optional frequencies . . . . . ± 0.35 dB

Frequency, see Section 1.2., "Readout Accuracy of Send Frequency"

Output

Output impedance, balanced, floating . . . . . 600 Ω

If requested when ordering, switchable between 600 Ω and one other value, see Section 1.6., "Switch-over Possibilities for Output Impedance".

Return loss . . . . . ≧ 40 dB
Receiver signal balance ratio . . . . . ≧ 46 dB
Voltage insulation to ground . . . . . 100 V d.c.

1.4. Receiver specifications

Input
Input impedance, balanced, floating . . . . . 600 Ω

If requested when ordering, switchable between 600 Ω and one other value, see Section 1.6. "Switch-over Possibilities for Output Impedance".

Return loss . . . . . ≧ 40 dB
Receiver signal balance ratio . . . . . ≧ 46 dB
Voltage insulation to ground . . . . . 100 V d.c.

Indication of measured variable

Analog meter readings of group delay distortion, attenuation frequency distortion and level selected as wanted by means of measurement mode switch

Digital readout, at choice, for receive or transmit frequencies.

Measuring ranges

Group delay distortion . . . . . ± 50 µs, ± 100 µs, ± 200 µs, etc. to ± 10 ms

Additionally . . . . . - 5 ms to + 15 ms

Attenuation frequency distortion . . ± 0.5 dB, ± 1 dB, ± 2 dB etc. to ± 50 dB

Level . . . . . - 50 dBm to - 30 dBm, - 40 dBm to - 20 dBm, - 30 dBm to - 10 dBm, - 20 dBm to 0 dBm, - 10 dBm to + 10 dBm

Frequency . . . . . 200 Hz to 20 kHz

Level and frequency readings are switchable by means of push button changing from measuring level/measuring frequency to reference level/reference frequency.

Accuracy limits of the Receiver

(contribution to the accuracy limits according to Section 1.2.)

Group delay distortion

Zero point and variation with frequency in frequency range:

1 kHz to 20 kHz	≦ 4 µs
600 Hz to 1 kHz	≦ 9 µs
400 Hz to 600 Hz	≦ 27 µs
200 Hz to 400 Hz	≦ 90 µs

Accuracy of readings

In temperature range + 15 °C to + 35 °C	± 2 % f.s.d.
Under conditions of rated range of use	± 4 % f.s.d.

Uncertainty of readings

R.M.S. value of fluttering readings due to impairments introduced by white noise having 4 kHz bandwidth and 26 dB signal-to-noise ratio referred to measuring or else reference signal

in position FAST	60 µs
in position SLOW	20 µs

Peak value of flutter due to impairments introduced by sinosoidal oscillations with 26 dB signal-to-noise ratio referred to the measuring or else reference signal and a separation Δf from the measuring or else reference frequency in position SLOW

for: Δf = 150 Hz	20 µs
Δf = 200 Hz	2 µs

Attenuation frequency distortion

Variation with frequency . . . . . ± 0.1 dB
Accuracy of readings . . . . . ± 3 % f.s.d. ± 0.05 dB

Receive level (after 1 hour warm up)
(compare with Section 1.2., "Accuracy Limits of the Receive Level).

In temperature range + 15 °C to + 35 °C
and level range – 20 dBm to + 10 dBm
at frequency point 1.8 kHz (CCITT Recommendation O.81) . . . ± 0.25 dB
for optional frequencies . . . . . ± 0.35 dB

Under conditions of rated range of use
at frequency point 1.8 kHz (CCITT Recommendation O.81) . . . . ± 1 dB
for optional frequencies . . . . . ± 1.1 dB

Frequency
(compare with Section 1.2., "Accuracy Limits of the Receive Level"

1.5. Specifications of operating modes which are not the same as the usual operating method

Level off, Impedance = Z_o

Generator

Operational as described under Section 1.3., "Specifications of the Generator", however, with blanked level. In this position, the Generator can serve as a termination for the test specimen which might be needed for other measuring purposes.

Blanking attenuation . . . . . ≧ 80 dB

Receiver

Operational as descibed under Section 1.4., "Specifications of the Receiver". Since the receiver input is passive, it can serve as a termination for the test specimen which might be needed for other measuring tasks. Any readings which perhaps may appear on the meter, thereby, are meaningless.

Modulation OFF

Generator

Operational as described under Section 1.3., "Specifications of the Generator", however, both of the modulating frequencies of 41.66 Hz and 166.66 Hz as well as the change-over frequency 4.166 Hz are switched off. The Generator section behaves as though it were a source of levels and frequencies.

Receiver

Operational as described under Section 1.4., "Specifications of the Receiver".

Retransmission (Remodulation)

This mode of operation serves to transfer the measured results obtained from the Receiver so that a different end, preferably the sending end, is provided with the measurements. Thus, a second Receiver at the end can be used for evaluating the retransmitted results. See Section 2.6.

Generator at far end

All modulation frequencies are switched off, only the reference frequency is transmitted.
The send signal is modulated with the envelope of the signal obtained at the Receiver. And therefore all of the information pertaining to group delay and attenuation frequency distortion is contained in the envelope.

The Generator level corresponds to the sum of the settings for Receive level plus Generator level.
All remaining Generator functions are as described under Section 1.3., "Specifications of the Generator", however, the possibility of blanking the Generator is nonfunctional.

Receiver at the far end

Operational as described under Section 1.4., "Specifications of the Receiver".

Accuracy limits for the evaluation of the retransmitted signal.

Group delay distortion

The same as for the Receiver doing the measuring as under Section 1.4. "Accuracy limits of the Receiver"

Attenuation frequency distortion

The same as for the Receiver doing the measuring as under Section 1.4. "Accuracy limits of the Receiver"

Additional error due to meter. . . . . ± 3 % f.s.d. ± 0.05 dB

Send level
Deviation from receive level plus send level setting . . . . . ± 1 dB

Remote control

This mode of operation serves for transferring the setting data to a Generator located at the far end, preferably control is at the receive end. Thereto, the Receiver signal obtained at the far end is processed with respect to settings for the measuring and reference frequencies as well as level of the Generator, see para. 2.9.1.

To be observed: This operating mode is only possible when the corresponding accessory device: "Remote Control" BN 691/11 is built into the LD-30 Measuring Set at the far end.

Generator at far end

Operational as described under Section 1.3., "Specifications of the Generator", however, the measuring and reference frequencies take on the values which are applied to the Receiver input.

The Generator level corresponds to the sum of the level of the reference signal at the Receiver plus the Generator level setting.

Receiver at the far end

Operational as described under Section 1.4., "Specifications of the Receiver".

Accuracy limits of the remotely controlled measuring variables.

Measuring frequency

Deviation from received value . . . . . ± 2 Hz

Reference frequency

Deviation from received value . . . . . ± 5 % ± 20 Hz

Level

In range −30 dBm to +1 dBm of the received (controlling) level of the reference signal.
Deviation from the received value plus send level setting . . . . . ± 0.8 dB

Speech facility

Herewith, it should be noted that the in-built loudspeaker is operational for all measuring modes.

Independent of the measuring mode TALK , selection can be made by means of switching either "2 wire output" or "2 wire input" as to whether the loudspeaker is to be connected at the Generator or at the Receiver. Accordingly, this is done depending on whether a two wire circuit is at the send end or at the receive end.

However, in the position 4 WIRE, the loudspeaker is connected for every operation mode at the Receiver.

If the loudspeaker is connected at the Generator, then when the termination of the output is correct, the measuring signal is somewhat suppressed, and it is weaker than the respective receiver speech.

If the loudspeaker is connected at the Receiver, then an automatic compressor reduces the received measuring signal (which according to choice can be internally adjusted to be between 100 % and approx. 30 %) after about 1 second, whereas the speech signal remains unaffected.

Independent therein whether the transmission path is set-up as two or four wire, the speech mode itself uses either two or four wire speech facilities (see section 1.5., "Specifications of the Connection Terminals for Speech Facility and X-Y Recorder").

TALK, "2 WIRE OUTPUT"

For this, the Generator is internally separated. Two-wire speech facilities are directly applied to the output (selection is possible).

Four-wire speech facilities are connected via a hybrid circuit at the output.

The Receiver is unrestricted operationally.

TALK, "2 WIRE INPUT"

For this, the Receiver is internally separated. Two-wire speech facilities are directly applied to the input (selection is possible).

Four-wire speech facilities are connected via a hybrid circuit at the input.

The Generator is unrestricted operationally.

TALK, "4 WIRE"

For this the Generator is separated, however, the Receiver is unrestricted for measuring.

Two wire speech facilities are separated via hybrid circuits in the speak and listen sections, and the connections are of the type as for the four wire mode. So the speech section is at the Generator output, and the listening section is applied parallel to the internal loudspeaker.

Specifications of the Connection Terminals for Speech Facilities and X-Y Recorder

Speech facility

Two wire speech facility
Either a desk telephone or a field telephone (e.g. OB-70)
Input impedance of the connection . . . . . approx. 600 Ω

Four wire speech facility
Either a microphone and the in-built loudspeaker or a handset.

Microphone MD 430/2
Sensitivity . . . . . approx. 0.2 mV/μ bar
Z_{out} = 200 Ω
Input impedance of microphone connection . . . . . approx. 1 kΩ

Handset (e.g. Siemens S 30368-Z 101-A 212)

Input impedance of the handset connection . . . . . approx. 300 Ω

Microphone current supplied by LD-30

A coarsely calibrated potentiometer permits the speech level to be adjusted on the line for the four wire speech facility
Adjustment range: . . . . . approx. 25 dB

X-Y recorder connection

Calibration of an X-Y recorder is possible for the zero point in the X and Y direction and for full scale deflection in the Y direction (full scale deflection of Y at set-in frequency) by means of push buttons.

Y-direction

The output voltage is proportional to the deflection on the meter scale.

± Full scale deflection corresponds to: . . . . . ± 2.5 V
Output impedance of Y output . . . . . 5 kΩ

X-direction

The frequency proportional output voltage is, according to the selected output of the send or receive frequency, independent of the reading on the digital readout.
d.c. to 20 kHz corresponds to: . . . . . 0 to + 5 V
Output impedance of the X output . . . . . 5 kΩ

1.6. Specifications of the Accessory Devices for the LD-30

Remote control device BN 691/11

Provided as three extra printed circuit boards for remotely controlling the measuring frequency, reference frequency and level. See Section 1.5.

Dial tone blocking filter BN 691/12

The dial tone blocking filter is provided as an additional printed circuit board.

Number of blocked frequencies . . . . . max. 2
Blocked frequencies, optionally selected in range . . . . 1.6 kHz to 20 kHz

Stop-band range, referred to the respective blocked frequency . . . . ± 150 Hz

Crystal controlled time base for frequency counter BN 691/13

Provided as two additional printed circuit boards "1 MHz oscillator" and "Frequency divider".

Accuracy limits of the crystal time base . . . . . ± 0.001 % ± 1 digit

D.C. loop-holding circuit BN 691/14

The d.c. loop-holding circuit is provided as an additional printed circuit board for each Generator and Receiver.

Maximum permissible holding current . . . . . 100 mA
Voltage drop across the holding circuit at maximum current . . . . . 13.5 V

Dynamic internal impedance in the range 200 Hz to 20 kHz . . . . . 60 kΩ
Impedance balance ratio . . . . . approx. 50 dB

Low pass filter BN 691/15

The low pass filter is available as an additional printed circuit board

The low pass filter aids in reducing the noise interference and for rejecting the 16 kHz metering-counter pulses

Additional group delay error to 4 kHz . . . . . ≦ 10 µs
Additional attenuation distortion to 4 kHz . . . . . ≦ 0.1 dB

Switch-over possibility for the internal impedance

Provided as additional printed circuit board for common switch-over of Generator and Receiver output and input impedances respectively between 600 Ω and some other values.

The following combinations are available:

600/150 Ω	Card 691-AG
600/400 Ω	Card 691-AH
600/800 Ω	Card 691-O
600/900 Ω	Card 691-AJ

1.7. General specifications

Ambient temperature
Limit range for storage and transport . . . . . - 40 to + 70 °C
Rated range of use (≅ Limit range of use) . . . . . + 5 to + 50 °C

A.C. line connection
Settings at line voltage selector . . . . . 110/117/127/220/227/235 V

A.C. line frequency . . . . . 45 to 66 Hz

Power consumption . . . . . 77 VA

Dimensions	Bench model		19" rack mounting (DIN 41494)	
	Width with handles	478 mm	Width	433 mm
	Height overall	155 mm	Height	131 mm
	Depth with handles	407 mm	Depth	353 mm

Weight (without accessory devices). . . . . .approx. 14.5 kg
FTZ-K-Number 272 775 804

1.8. Order numbers

Group Delay and Attenuation Measuring Set LD-30 . . . . . BN 691
Group Delay and Attenuation Measuring Set LD-30
(send level max. approx. + 1 dBm, output and input
impedances for Generator and Receiver, only 600 Ω) . . . . . BN 691/3

Options (available at extra cost)

Remote control device . . . . . BN 691/11
Dial tone frequency blocking filter. . . . . BN 691/12
Crystal controlled time base for frequency counter . . . . . BN 691/13
D.C. loop-holding circuit (provided for
Generator and Receiver respectively) . . . . . BN 691/14
Low pass filter . . . . . BN 691/15

Switchable output/input impedances of: 600/150 Ω
600/400 Ω
600/800 Ω
600/900 Ω
selectable

Microphone . . . . . MD 430/2+K 194

Subject to change without notice

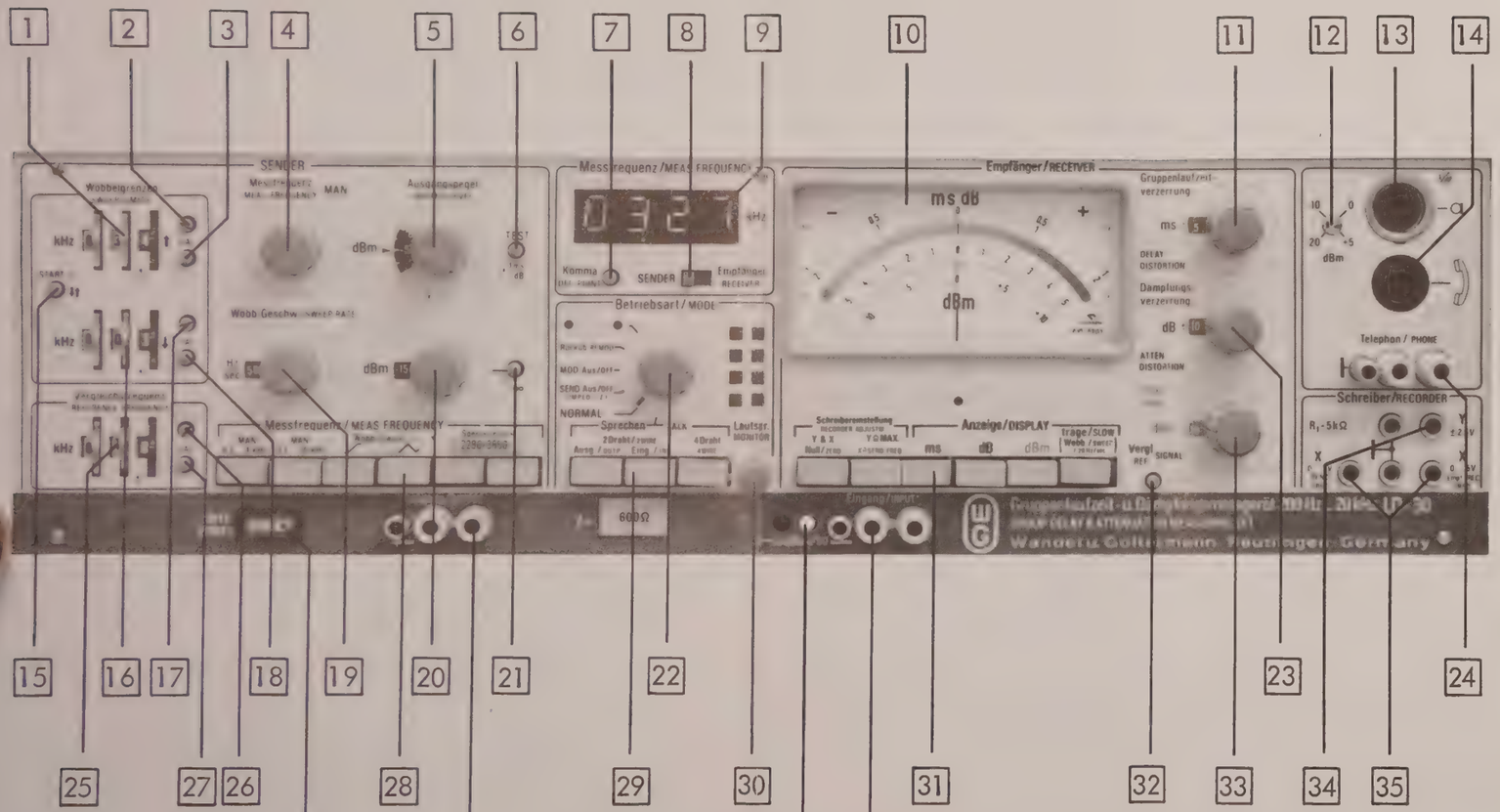

Fig. 2-1 Front view of LD-30 Measuring Set

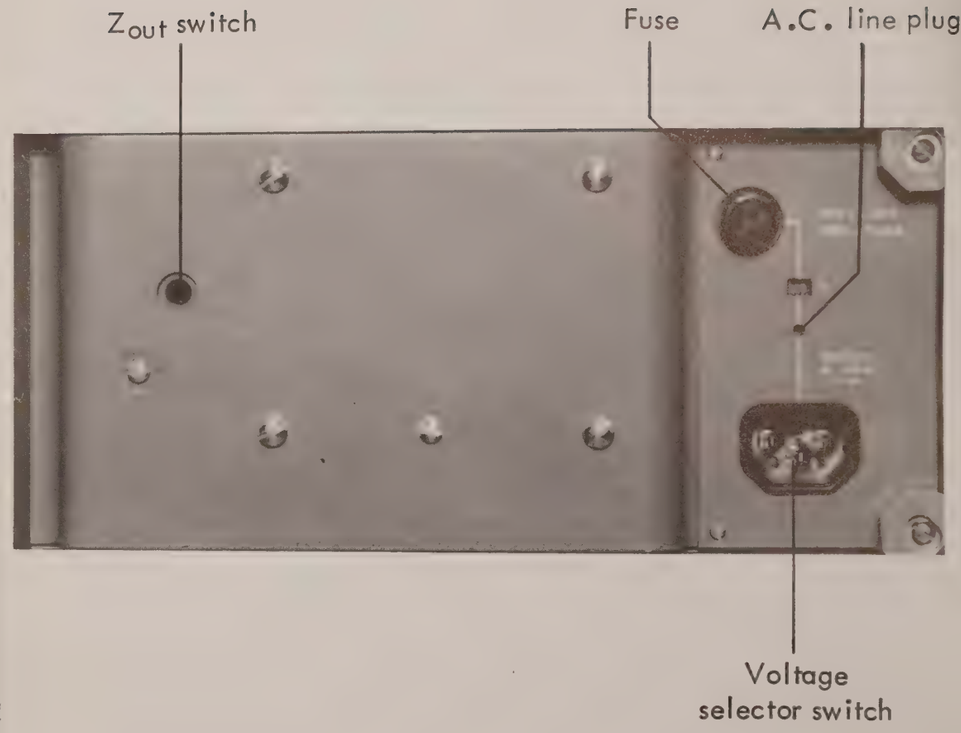

Fig. 2-2 Rear view of LD-30 Measuring Set

2. OPERATION

2.1. Operating controls

The operating controls, indicating devices and connectors on the front panel are arranged from the functional point of view. On the back panel of the Set are the a.c. power line connnector, a.c. line voltage selector and equipment fuse. Exact labeling and the use of graphical symbols provide the functional relationships of the defined operating controls and assure thereby correct operation of the measuring equipments.

The functions of the operating controls are described in the following table whereby the numbers given in column 1 of Fig. 2 are used for identifying the operating controls.

References to the operating controls' designations used in the circuit diagrams are listed in the second column.

Therefore the front panel is presented unambiguously arranged so for every push button area only one identification number is assigned; e.g. [28] . The individual push buttons of a push button field are consecutively numbered from left to right in the operating manual; e.g. push button [28] 1 to push button [28] 6.

Identification number for operating control	Designation found in circuit diagrams	Function
[1]	S 2202	Digital setting of the upper sweep limit in range 200 Hz to 19.9 kHz in 100 Hz increments
[2]	P 2201.2	Vernier adjustment for the upper sweep limit by ± 150 Hz with depressed button [3] .
[3]	S 2502	Depressing button causes the measuring frequency to take simultaneously that value of the upper sweep limit displayed on [9], defining the upper sweep limit as the initial value when sweeping.
[4]	P 2503	Manual setting of the measuring frequency, consequent to frequency range selection, via push button [28] 1 or [28] 2 and simultaneous counter display [9] .

5	P 2307	Level fine adjustment with calibrated potentiometer continuously from – 6 dBm to + 1 dBm.
6	S 2401	With depressed push button: the reading at the Receiver changes by approx. + 1 ms or approx. + 1 dB.
7	S 2601	When depressed: the counter frequency readout resolution is changed-over from 10 Hz to 1 Hz thereby eliminating the 10 Hz position.
8	S 501	Change-over of frequency readout from send frequency to receive frequency.
9		Frequency readout of the received measuring frequency, or via push button 27 the received reference frequency with 10 Hz resolution through 4 seven segment figures.
10	J 301	According to the chosen push button 31 3 or 31 4, group delay distortion or attenuation frequency distortion is indicated on either of three scale ranges on the Receiver meter, and also via push button 31 5 and the meter's blue scale for absolute receive level.
11	S 305	Nine measuring ranges for group delay distortion; eight of these ranges attain f.s.d. from ± 0.05 ms to ± 10 ms. In step 9 the measurement range ± 10 ms is offset by + 5 ms so then the scale is – 5 ms to + 15 ms.
12	P 605	Level matching for microphone or microphone capsule in handset: range from – 20 dBm to + 5 dBm
13	Bu 602	Microphone connector; 5 pole. See note page 2-20.
14	Bu 603	Connector for handset (e.g. Siemens S 30368-Z 101-A 212).
15	S 2504	Start button for single shot sweep whereby the push button actuates the single or periodic sweep which results immediately after a reversal of direction of the sweep voltage.
16	S 2201	Digital setting of the lower sweep frequency in range 200 Hz to 19.9 kHz in 100 Hz increments.
17	P 2201.1	Vernier adjustment of the lower limit by ± 150 Hz with depressed push button 18.

18	S 2503	Depressing button causes the measuring frequency to take simultaneously that value of the lower sweep limit displayed on the counter readout 9 ; defining the lower sweep limit as the initial value when sweeping.
19	S 2505	Selection switch for sweep rates from 10 to 200 Hz/s.
20	S 2301	Coarse level adjustments in 5 dBm increments from – 45 dBm to + 10 dBm.
21	S 2205	Send level is blanked when push button is depressed. It permits checking the measuring circuit, or it can be used as an arranged code to signal during measurements (e.g. signal for end of measurement).
22	S 604	Mode selection switch Normal: Measurement of group delay and attenuation frequency distortion and receive level (carrier change-over and modulation switched on). Talk: Puts speech facility into operation. Two or four wire operation through preselection with push buttons 29 1 to 29 3 (see 29). Mod. off: Switches off modulation of send signal; that is 41.66 Hz and 166.66 Hz as well as 4.166 Hz carrier change-over between reference and measuring frequencies. The Measuring Set can be used as AF and swept frequency Measuring Setup. Remod: Retransmission to the near end the measured result obtained at the far end. Position REMOD is to be selected on the Measuring Set LD-30 at the far end (see section 2.6.). Remote: (auxiliary facility available on request). Remote control of the sender at the far end. The adjustment values for the measuring frequency, reference frequency and level adjustment are provided by the Generator at the near end. Setting : Remote should be selected on the Measuring Set LD-30 at the far end. (see section 2.9.1.)

23	S 304	Seven measuring ranges for attenuation frequency distortion from ± 0.5 dB to ± 50 dB.
24	Bu 601	Connector for telephone, either desk set or field-phone.
25	S 2203	Digital setting of the reference frequency in 100 Hz increments from 400 Hz to 19.9 kHz.
26	P 2201.3	Fine setting by ± 150 Hz of reference frequency within the 100 Hz increments of switch 25 with depressed switch 27.
27	S 2501	Button depressed: the reference signal is sent during the measuring cycle as well as the reference cycle, and its value is displayed.
28	S 2506	Measuring frequency selector push buttons.
28 1		When depressed: the measuring frequency can be manually tuned from 200 Hz to 4 kHz by means of potentiometer 4.
28 2		When depressed: the measuring frequency can be manually tuned from 200 Hz to 20 kHz by means of potentiometer 4.
28 3		One shot sweep; sweeping is started with push button 15.
28 4		Start for periodic sweeping; sweep limits set via preselector switches 1 and 16.
28 5, 28 6		With internal dial tone frequency filters, these push buttons switch the filters in and out.
29	S 601	TALK selector switches
29 1	S 601/I	When depressed: the Generator is internally separated, "two wire" speech facility is located directly at Generator output (selection is possible). Information can be received in any operating mode. "Four wire" speech facility is applied via a hybrid circuit to the output. The Receiver is not restricted in capability.
29 2	S 601/II	When depressed: the Receiver is internally separated, "two wire" speech facility is directly applied to Receiver input (selection is possible). "Four wire" speech facility is applied via hybrid circuit to Receiver input. Via switch

		[22] SPEAK, information can be sent to the other end. The Generator remains completely functionaly.
[29] 3	S 601/III	When depressed: "four wire" speech facility via switch [22] TALK is possible when an additional Set at the end of the path has the same settings on [29] 3 and [22] .
[30]	P 601	Volume control for loudspeaker in TALK mode.
[31]	S 302	DISPLAY and RECORDER push button selectors.
[31] 1	S 302/1	When depressed: signals are applied to connectors [34] , [35] for zero point alignment of an X-Y recorder.
[31] 2	S 302/2	When depressed: a d.c. voltage is applied at connector [34] ; at the selected frequency it causes full scale deflection on meter [10] and on the X-Y recorder.
[31] 3,4,5	S 302/3/4/5	Change-over of the meter readings and the Y output for group delay distortion or attenuation frequency distortion or receive level.
[31] 6	S 302/6	Change-over from fast to slow meter readings for suppressing the disturbances from the test specimen. The change-over also is effective at the X-Y recorder outputs and the frequency readout.
[32]	S 301	When depressed: instead of the measuring signal's input level, the level of the reference signal is indicated on the meter or the reference frequency is displayed on the frequency readout when switch [8] is placed in position RECEIVER.
[33]	S 303	Measurement range switch for receive level measurements from - 40 dBm to 0 dBm.
[34]	Bu 301	Y output for X-Y recorder connection: It can be extracted as a d.c. voltage proportional to the measured value according to the selected push button [31].
[35]	Bu 2501 Bu 501	X output for a d.c. voltage proportional to the Generator frequency. X output for a d.c. voltage proportional to the receive frequency.

A.C. line power	S 101	ON-OFF switch (in ON position, the switch cap appears red).
Output	Bu 2301	Generator output, connector for the test specimen.
Z =		Specification for impedance of Generator output and Receiver input. If the Set is fitted with two impedances, then the switched-in value is indicated by a LED
< - 50 dBm >+ 10 dBm	Gl 209 Gl 210	Input level monitor. If the lower or upper threshold is violated, then the respective lamp illuminates.
Input	Bu 201	Receiver input, connection for the test specimen.

2.2. "Connecting up" and putting into operation

The a.c. line connection is made by means of the line cable stored in the bottom of the LD-30. Behind the hinged bottom of the case there is storage space for the Operating Manual of the LD-30 Measuring Set. Additionally, a microphone can be stored in the space.

The LD-30 is suitable for use on a.c. lines with frequencies between 45 Hz and 66 Hz. It is factory set for 220 V operation, but the a.c. line voltage selector switch can be changed by means of a screw driver to 110, 117, 127, 227 or 235 V. The selected value of voltage is visible through a cut-out above the selector switch, see Fig. 2-2.

When changing over to a.c. line voltage values of 110, 117 and 127 V the fuse element must be changed to a different value, see Table 2-1.

A.C. line voltage	Fuse
220, 227, 235 V	T 0.63 B (0.63 A, slow-blow)
110, 117, 127 V	T 1.25 V (1.25 A, slow-blow)

Table 2-1

2.3. Operating the Generator

2.3.1. Level setting

The coarse setting of the send level in range - 45 dBm to + 10 dBm is done with switch [20] in 5 dBm increments. Simultaneously, measurement MODE switch [22] must be placed in position NORMAL. The adjustment values from - 45 dBm to + 10 dBm can be read at the calibrated switch knob [20] .

A version of the LD-30 with reduced level of 0 dBm and 600 Ω for measuring on data lines is available. Permission for use on administrations' facilities or those of operating companies' are individual situations arising in the various countries and should be handled on an individual basis in the country concerned.

Send level can be varied continuously from - 6 dB to + 1 dB with the 0.5 dB increments of calibrated potentiometer [5].

The actual level is provided by algebraic addition of the adjusted value of switch [20] plus potentiometer [5] . The Generator has a balanced and floating output with an output impedance of 600 Ω (if specially requested, an additional value of 150, 400, 800 or 900 Ω is possible).

2.3.2. Frequency setting and readout

Measuring frequency ranges are selected by means of push buttons [28] 1 and [28] 2 for the ranges 200 Hz to 4 kHz and 200 Hz to 20 kHz. The measuring frequency is adjusted through potentiometer [4] and is readout via an internal frequency counter with a 4 digit display when switch [8] is placed in position SENDER. Push button [7] changes over the counter readout from a resolution of 10 Hz to that of 1 Hz, whereby the 10 kHz position of the readout is eliminated. The reference frequency in range 200 Hz to 19.9 kHz is adjustable in 100 Hz increments by means of the preselector switch [25] .

Within the 100 Hz increments the reference frequency may be adjusted more finer with a screw driver adjustment at potentiometer [26] .

Depressing push button [27] causes change-over of the internal frequency counter so the reference frequency is measured and displayed instead of the measuring frequency.

Thereby the reference signal is changed over in the measuring cycle.

Adjusting and reading out the upper and lower limits is done by the same means as with the reference frequency.

2.4. Operating the Receiver

2.4.1. Input level range and monitoring it

The signal coming from the test specimen is applied to the Receiver input which is balanced and floating. Input impedance is 600 Ω (if specially ordered, also 150, 400, 800 or 900Ω). The permissible range of input level extends from - 50 dBm to + 10 dBm.

It is not necessary to match the sensitivity of the Receiver to the input level, however, the measuring mode switch [22] must be switched to NORMAL. Violations of the lower and upper threshold of the permissible level range are indicated by LED's

The input level of the measuring or reference signal can be measured absolutely and read on meter [10] (see section 2.4.3.3.).

2.4.2. Frequency readout

The received measuring frequency (200 Hz to 20 kHz) is displayed with a resolution of 10 Hz when switch [8] is in position RECEIVER. Push button [7] provides 1 Hz resolution whereby the 10 kHz position in the readout is eliminated. The reference frequency is displayed when push button [32] is depressed.

2.4.3. Indication of measured result

Meter [10] which has four scale ranges can provide readings according to which push button [31] 3 to [31] 5 is depressed for the measured group delay distortion and attenuation frequency distortion (black scale) or the absolute input level (only the blue scale).

Push button [31] 6 can change over the measured result from fast to slow so as to suppress disturbances introduced by the test specimen.

2.4.3.1. Group delay distortion $\Delta\tau_g$

Group delay distortion originating in the test specimen is measured with depressed push button [31] 3 and is read on meter [10] .

Measuring range switch [11] provides a choice of 9 measuring ranges. From ± 0.05 ms to ± 10 ms there is a choice of 8 ranges. In position 9, the range ± 10 ms has + 5 ms added to it. Thereby the receiver permits group delay distortion additionally to be measured - 5 to + 15 ms. This causes the meter pointer to be offset so the 0 is read at - 5 ms.

The selectable ranges are referred to plus or minus full scale deflection of the meter.

According to the selected range the measured result is read on one of the three black scales.

2.4.3.2. Attenuation frequency distortion Δa

Push button [31] 4 is depressed to measure attenuation frequency distortion which is read on meter [10] . Switch [23] permits 7 measurement ranges to be selected for attenuation frequency distortion between ± 0.5 dB and ± 50 dB.

The selectable ranges are referred to the plus or minus full scale deflection of the corresponding black scale on meter [10] .

2.4.3.3. Receive level

Measuring the receive level is possible with depressed push button [31] 5. The level range of 5 increments from - 40 dBm to 0 dBm is selectable with level range switch [33] .

The meter indicates the level of the carrier signal at the measuring frequency. The level of the reference can be read on the meter after push button [32] is depressed.

2.5. Measuring

For examining the variations with frequency of group delay and attenuation distortion of a test specimen , the method of sampling carriers is applied. Thus the measured results are referred to the reference frequency. Thereupon, as a result the absolute values of group delay and attenuation frequency distortion are not obtained, but

instead their differences with reference to the values at the reference frequency.

The LD-30 Measuring Set permits easy measurements to be made in the loop-back procedure where Generator and Receiver are located at the same end.

End-to-end measurements are possible when a second LD-30 Set is used or else due to using the identical measuring principle, Measuring Setups LD-2 or LD-3 can be used. Since every LD-30 Measuring Set is equipped with a speech facility, it is possible to converse over two wire or four wire systems without additional lines being used. This is possible if at the far end an LD-30 Measuring Set or a Measuring Set LD-3 with Speech Facility LDZ-3 is present.

2.5.1. Point-to-point measurements, measurements with manual frequency settings

During measurements, it should be noted that the send level should be selected as high as possible in order to obtain a high signal-to-noise ratio. Thereby it is necessary to observe the overload characteristic of the system to be measured. There are no modern systems in use which make use of a send level over 0 dBm. If measurements are made on postal administration lines, then of course the corresponding prerequisites must be observed.

The reference frequency can be freely chosen within the transmission range of the test specimen. However, CCITT Recommendations provide information as to which reference frequencies are preferred for use. Thus the new CCITT equipment specification for a group delay and attenuation frequency distortion measuring setup is recommended to be 1.8 kHz.

For measuring the attenuation frequency distortion on circuits according to the CCITT Recommendation M.102, a reference frequency of 800 Hz should be used. The reference frequency for the group delay should be chosen according to M.102 so that it occurs at the minimum point of the curve to be plotted.

The measuring frequency can be manually varied in the selected frequency range.

The measuring configuration for level, attenuation frequency distortion and group delay distortion is shown in Fig. 2-3

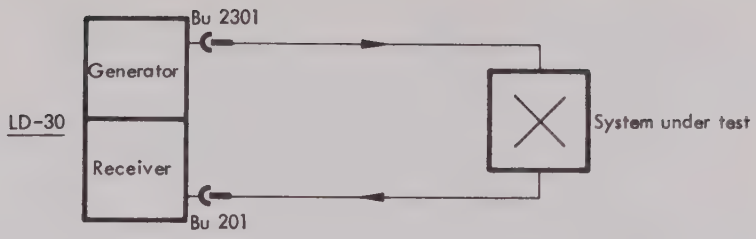

Fig. 2-3 Measuring configuration for loop-back measurements

The following settings for the measurement of level, group delay distortion and attenuation frequency distribution:

- Measurement mode switch [22] in position NORMAL
- Switch [8] in position SENDER
- Push buttons [28] 3 to [28] 6 may not be depressed
- Selection of the frequency range via push button [28] 1 or [28] 2, the selected measuring frequency is displayed on readout [9].
- Send level adjusted via switch [20] and potentiometer [5]
- Connect test specimen, check the receive level for violation of upper or lower threshold of input level at the two LEDs.

The Measuring Set LD-30 is ready for operation for point-to-point measurements. Only the measurement mode with the corresponding measuring range selection remains.

2.5.1.1. Level measurement

The input levels of the measuring and reference frequencies are in the range from - 50 dBm to + 10 dBm.

For level measurements accordingly the following adjustments are required:

- Measurement range switch [33] adjusted to high value level
- Depress push button [31] 5 and read level on blue scale of meter [10], change switch [33] according to need for resolution.

The absolute level is the sum of the algebraic addition of level setting value and meter reading value.

2.5.1.2. Attenuation frequency distortion

The following adjustments are necessary:

- Reference frequency adjusted with preselector switch [25] either by choice or according to CCITT Recommendation (see section 2.5.1.). Check by means of frequency readout with depressed push button [27] ; can be corrected with potentiometer [26] if required.
- Depress push button [31] 4 and set switch [23] to a high range of attenuation frequency distortion. If the resolution is not satisfactory, raise the sensitivity.
- Vary measuring frequency via potentiometer [4] in adjusted frequency range.

With point-to-point measurements the possibility is offered of plotting the measured values on a prepared attenuation frequency distortion tolerance template. See recorder operation, section 2.5.2.1.

2.5.1.3. Group delay distortion measurement

The following adjustments are again required:

- Reference frequency adjusted with preselector switch [25] either by choice or according to CCITT Recommendation (see section 2.5.1.). Check by means of frequency readout with depressed push button [27] , fine adjustment with potentiometer [26] .
- Depress push button [31] 3 and set indication range switch [11] to a high group delay distortion.
- Vary measuring frequency via potentiometer [4] in adjusted frequency range. If resolution of measured value is not satisfactory, then the sensitivity can be readjusted with switch [11].

The required measured values can be plotted on a prepared group delay distortion template. See recorder operation, section 2.5.2.1.

With measurements of group delay distortion, a level difference is observed to occur between measuring signal and reference signal. The group delay distortion errors, in the Receiver, caused by this attenuation difference between the measuring and reference signals are given in sections 1.2. and 1.4.

Note : When changing over the frequency readout of measuring to reference frequency at the Generator section during point-to-point and swept frequency measurements, the readout of the measured result at the Receiver also changes. This is due to the reference frequency being sent and displayed, instead of the measuring frequency, in the measuring cycle. Correspondingly this also applies to the frequency readout of

upper and lower speed limits. When operating with an X-Y recorder, changing over the frequency readout without proper care at the Generator and Receiver could cause the recording pen to jump violently and cause the plotted curve to be disturbed.

2.5.1.4. Test circuit

Rapidly verifying the functions of an LD-30 is possible because it has a test circuit facility which permits use either with direct connection of Generator and Receiver or else with a connection through the test specimen.

When push button [6] is depressed at the Generator, the meter at the Receiver, depending on positions of push buttons [31] 3 or [31] 4, provides readings of approx. +1 ms or approx. +1 dB. However, if the test specimen is located between Generator output and Receiver input, then the preceeding measured value has been added to the true measured result.

2.5.2. Swept frequency measurements

The knowledge of section 2.5.1. is also required for undertaking swept frequency measurements. Send level- and reference frequency - adjustments are made as with point-to-point measurements.

At the Generator, the lower and upper sweep limits are selected by means of the preselector switches [16] and [1]. The fine settings of sweep limits are done with push buttons [18] and [3] as well as potentiometers [17] and [2] as already described in section 2.3.2.

Since during swept frequency operation the measuring ranges for the indication of group delay and attenuation distortion if possible should not be switched, the measurement range switches [11] and [23] should be at such a high range that full scale deflection is not exceeded on the Receiver meter. For this procedure, manual tuning of the measuring frequency is done over the frequency range of interest.

However, before this the reference frequency was correspondingly adjusted for the measurement mode. When the range is selected, the highest measured value which appears is chosen as the guide.

Generally, however, the measured values are greatest at the band limits, so it is sufficient that depressing [3] and [18] in consecutive order causes the upper and lower sweep limits to be adjusted and measured.

Now switch [19] permits the choice of speed rate. However, the sweep rate is dependent on the response time of the test specimen. If the test specimen has a smooth frequency response, then it can be swept at a faster rate. But, so as not to miss a small,frequency variation, with a slow meter response a low sweep rate should be switched in, dependent on the transient response of the test specimen.

The type of sweep is determined with push buttons [28] 3 and [28] 4: single shot sweep [28] 3 for the selected frequency range or periodic sweep ([28] 4).

During a sweep run, push button [15] can be used to reverse the sweep direction. Furthermore, push button [15] is used to release a single shot sweep.

Whether the sweep run is to be started at the upper or the lower sweep limit is determined with push buttons [18] and [3].

2.5.2.1. Recorder operation

The measured results obtained from the sweep measurements can be recorded on an X-Y recorder. Three d.c. outputs are available on the Measuring Set LD-30. At Bu [35] a d.c. voltage proportional to the X axis can be extracted from either the Generator or the Receiver.

At Bu [34] a d.c. voltage signal corresponding to the X axis signal can be extracted. Push buttons [31] 1 and [31] 2 permit calibrating a recorder when connected to the LD-30.

Zero adjustment:

- Depress push button [31] 1, zero point adjustment is done at recorder according to particular recorder instructions and with recording paper in place.
- Release push button [31] 1

Full scale deflection calibration:

- Adjust with potentiometer [4] or via upper and lower sweep limits, the frequency limits to be measured so the max. X deflection is calibrated on the recorder.

- Depress push button [31] 2, calibrate for maximum Y deflection; check by means of the upper and lower frequency limits adjustment with potentiometer [4] or via the sweep limits. Y deflection corresponds to the adjusted frequency point.

- Release [31] 2.

Note: To assure obtaining an easily plotted curve either with the recorder or manually, Wandel u. Goltermann has prepared special diagram paper imprinted with the tolerance template of M.102 on DIN A 4 having at least 210x297 mm recording area. If desired, the pads of diagram paper can be ordered for attenuation frequency distortion and group delay distortion under the order numbers 5/402 and 5/403. These diagrams can also be applied with the Attenuation and Group Delay Equalizer DLZ-4.

For an impairment-free plotting of group delay and attenuation frequency distortion, the following measurement modes can be operated with an X-Y recorder. The various operating modes are:

Loop back measurement:

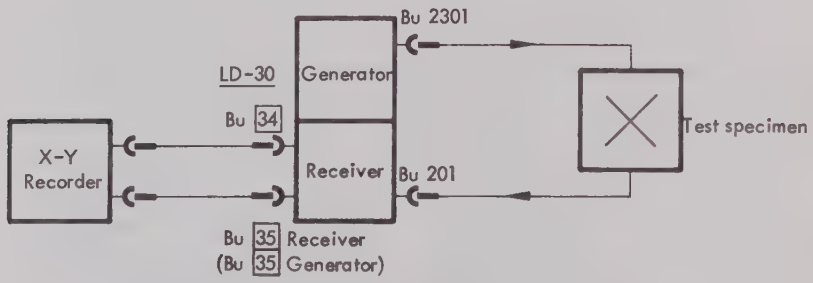

Fig. 2-4 Loop-Back measurement, with recording

If the signal from the test specimen is badly impaired by noise, the X deflection should be obtained from the X-SEND output whereupon a low-noise X deflection is achieved.

With retransmission of measurements, the X-Y recorder is driven for X deflection only from connector Bu [35] X-output SEND. This is necessary for a continuous plot because the retransmission signal is comprised of the reference signal as the carrier with the modulation test signal already having been conditioned by attenuation distortion and a phase jump. See Fig. 2-5.

Retransmission:

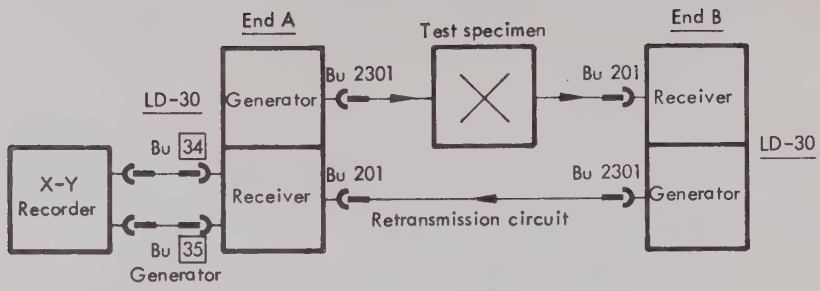

Fig. 2-5 Retransmission of measurement, with recording

For end-to-end measurement and remotely controlled measurements, the X-Y recorder is connected at the receive end.

An additional possibility, for connecting two X-Y recorders, is obtained when a four wire or two two-wire lines should be tested between end A and end B.

The measuring setup is illustrated in Fig. 2-6. Adjustments on the equipments are normally made or else can be made through use of the internal speech facility for conversing between end A and end B.

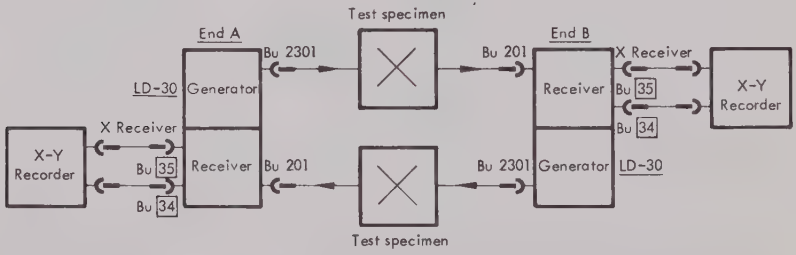

Fig. 2-6 Measurement from the near end to the far end and reversed, with recording

2.6. Return transmission of measured results

With end-to-end measurements a Receiver located at the far end B can provide group delay and attenuation results via a second Measuring Set LD-30 or LD-3 and another transmission channel to retransmit back to the near end A, the sending end. No

special requirements are placed on the retransmission circuit. The following circuit is to be set up for retransmission of the measured results.

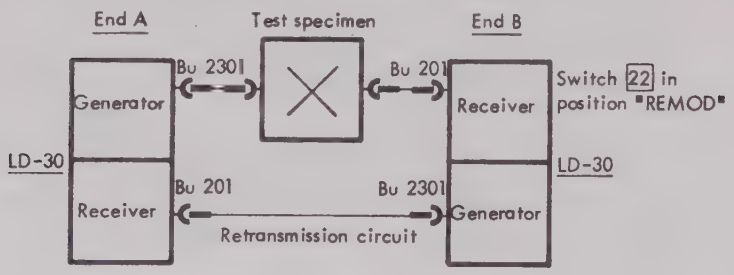

Fig. 2-7 Retransmission of measured results from end B to end A (also known as "remodulation")

The adjustments of the equipments at end A and at end B are given as an example for measuring the group delay distortion:

End A: Generator

- Measurement mode switch [22] in position NORMAL
- Switch [8] in position SENDER
- Choose frequency range via push button [28] 1 or [28] 2 ; the selected test frequency is displayed on readout [9]
- Select reference frequency with thumb wheel switch [25]
- Sweep limits selected at thumb wheel switches [1] and [16] and can be set via push buttons [3] or [18] and checked on readout [9]
- Send level adjusted via switch [20] and potentiometer [5]
- Connect test specimen
- Sweep rate is set with switch [19]
- Sweep mode selected with push button [28] 3 or [28] 4
- Either one or two dial tone blocking filters can be switched in with push buttons [28] 5 and [28] 6
- Push button [15] START is used for starting run, if depressed a second time the sweep direction is reversed for single shot or periodic sweeping.

For manual measurements, all operating controls used for sweeping are not used.

End A: Receiver

The adjustments are made as in section 2.5.1.3. for the measurements of group

delay distortion. An X-Y recorder is connected as in section 2.5.2.1. At end B, the Receiver outputs an envelope signal which has recovered the phase end attenuation jumps needed for modulating the reference frequency being retransmitted via the retransmission line back to the Receiver at end A.

End B: Adjustments on Generator and Receiver

- Switch [22] in position "REMOD"
- Adjustment of the reference frequency as with Generator end A (observe NOTE)

Note: The reference frequency for the retransmitted direction is not to be the same as that in the direction A-B. The frequency should be located in range from 2 kHz to 3 kHz.

- To readout frequency, switch [8] is placed in position SENDER
- Receiver operates as amplifier during retransmission. By means of switch [20] and potentiometer [5] level matching of the retransmitted signals is done. The retransmitted signal has the same level as the input signal at end B if switch [20] and potentiometer [5] are placed in position 0 dBm. Additionally, the retransmitted signal can be varied with switch [20] and potentiometer [5].

2.7. Speech facility

The speech facility is included in every Measuring Set LD-30 and can be used with two wire as well as with four wire circuits. It permits a simple connection for conversing between the two measuring ends and does not need an additional speech channel to be setup between the two ends. Easy operation of the speech facility increases the measuring security and measuring speed when the LD-30 Measuring Set is used. To prevent interference when a speech connection is setup, only one of the connectors [13] [14] or [24] may be occupied at any one time.

Push buttons [29] 1 to [29] 3 must be selected according to whether two or four wire lines are used as well as which direction is to be used for measuring. Push button [29] 1 TWO WIRE OUTPUT switches the Generator output simultaneously to be receiver for speech signals.

Push button [29] 2 TWO WIRE INPUT switches the incoming speech signals from the Generator output to the Receiver input.

A speech capability can be provided if two wire or four wire lines have been connected

and either a microphone, a handset or field telephone can be used. If speech capability is to be provided by a microphone, it is necessary to connect a microphone at end A and also one at end B.

Note: If microphones from other sources of supply are used with the speech facility, then it is necessary to ensure that there is always a jumper between point 4 and point 5 on Bu [13].

With two wire subscriber lines, the ordinary telephone set can be used for the speech connection. During measurements, an additional device, the "D.C. Loop Holding Circuit", will hold the d.c. loop through the exchange.

The following examples illustrate the versatile possibilities of the Speech Facility.

2.7.1. Fixed installed two wire connection

The measuring configuration is setup according to Fig. 2-8 with a fixed installed line between end A and end B. The presettings of push buttons [29] 1 and [29] 2 are selected as follows:

Push button [29] 1 is depressed at the send end, and push button [29] 2 is depressed at the receive end. Thus, the speech facility is definitely arranged so end A via the Generator output receives a speech signal from end B, and in the reverse direction end B receives a speech from end A. Moreover, end B issues voice instructions for adjusting the measuring equipment, so the following adjustments are made:

- End B switches measurement mode selection switch [22] to position TALK
- The microphone is connected to Bu [13]
- End B has the option of placing measurement mode switch [22] in position NORMAL or TALK
- End B now can dictate information to end A
- End A hears the information through an internal loudspeaker. Volume can be adjusted with potentiometer [30]
- End A now places switch [22] in position TALK.
  Either of three choices can be connected as at:

  Bu [13], a microphone

  Bu [14], a handset

  Bu [24], a field telephone

Now end A and end B can exchange conversation, e.g. adjusting the measurement range. At ends A and B, the switch [22] is placed in position NORMAL and measurements can be made.

The speech facility instruction arrangement also can be from end A to end B, if desired.

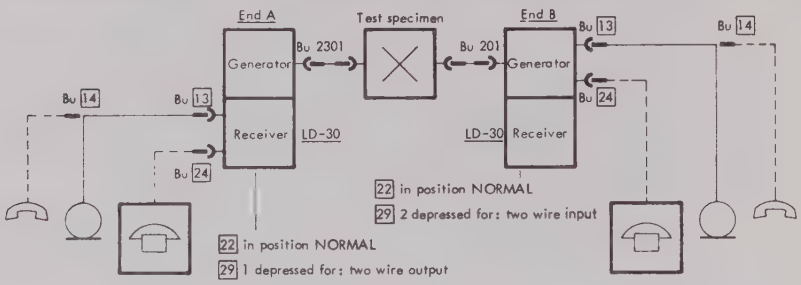

Fig. 2-8 End-to-end measurements on a two wire circuit

2.7.2. Two wire circuit with subscriber loop

The arrangement (see Fig. 2-9) of a test path with a subscriber circuit using normal telephones.

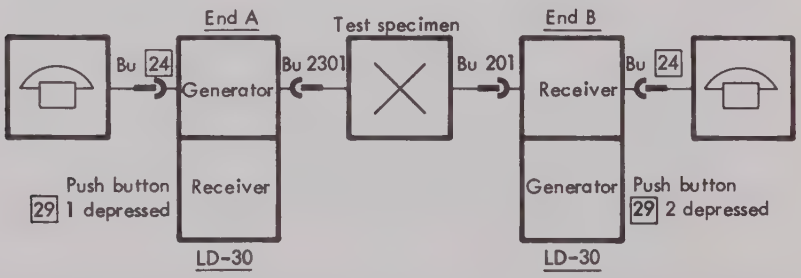

Fig. 2-9 End-to-end measurements on a two wire circuit with subscriber loop-through

The presettings of the speech facility are done via push button [29] 1 at the Generator and [29] 2 at the Receiver. The Measuring Sets LD-30 at end A and end B are switched to TALK with switch [22].

Establishing the circuit:

- End A dials the subscriber at end B

- Subscriber at end B picks up telephone handset, thereby setting up duplex conversation connection via the test specimen
- End A and end B clarify setting values for adjusting LD-30 Measuring Sets
- Switch [22] is placed in position NORMAL (Measuring Set LD-30 must be equipped with two D.C. loop-holding circuits BN 691/14), and now the loop-holding current is drained by the loop-holding circuits.
- During or after the measurement, end B makes an announcement, there to first the handset is picked up and switch [22] is placed in position TALK. End A hears from end B the announcement over the loudspeaker and does not switch any controls.

If, during the measurement on a subscriber line, change-over is made from NORMAL to TALK, then first the handset of the telephone at the end being spoken to must be picked up from the hook-switch. At the other end, if change-over is made, the same procedure is required.

2.7.3. Two wire circuit with duplex conversation during the measuring operation

If between end A and end B there is available two individual two wire circuits, then the LD-30 Measuring Set offers the possibility without interrupting the measurement that constant duplex conversation can be made over the second circuit. The arrangement is shown in Fig. 2-10.

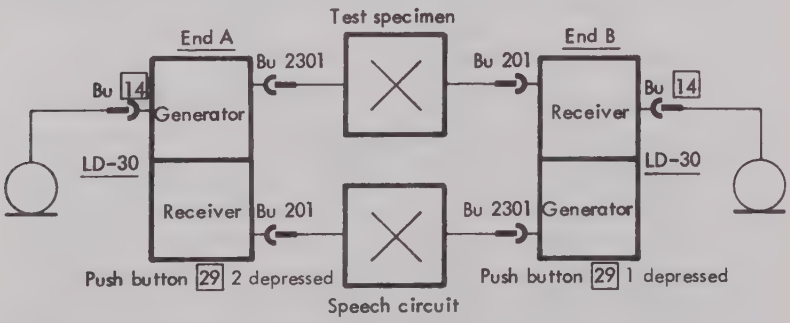

Fig. 2-10 End-to-end measurement with simultaneous duplex conversation

The LD-30 Measuring Sets used at end A and at end B are placed at switch [22] in position TALK. Push button [29] 1 is depressed at end B and push button [29] 2 is depressed at end A.

The measurement is made in the direction from end A to end B. The two wire circuit from end B to end A provides information by way of a microphone, a handset or a field telephone. The far end hears the information coming in over a loudspeaker and can immediately without switching-over answer back. Thus, the measurement is done in parallel and without interference from the speech circuit.

After the measurement has been made, the speech circuit and the test circuit can be interchanged so the former speech circuit can be measured. Thereto, the push buttons must be newly depressed to have push button [29] 2 instead of [29] 1 at end B, and at end A [29] 1 instead of [29] 2.

The advantage of this measurement mode is to provide fast measurements with simultaneous two way conversations.

2.7.4. End-to-end measurements on four wire circuits

Four wire circuits also can be used to carry speech when measurements are being made while using the speech facility of the LD-30 Measuring Set. Usually the lines in a four wire circuit are directional. When connecting to the LD-30, this directionality must be observed. Push buttons [29] 3 are depressed on the Measuring Set at ends A and B. The measuring configuration according to Fig. 2-11 offers two possibilities with the speech facility whereby a microphone, telephone or handset can be connected

2.7.4.1. Four wire system with speech circuit

This application is setup to measure directional circuits in a specific direction for instance from end A to end B, and in the reverse direction simultaneously speech is sent from end B to end A. For two way conversation, the measurements are interrupted.

The following settings are required:

- Switch [22] at end A in position NORMAL
- Switch [22] at end B in position TALK and a microphone is connected to connector [13].

End B can constantly announce the measured values, end A hears the announcements through the self contained loudspeaker. The operator at end A can make a return call,

but he must interrupt the measurement and do the following at the LD-30 Measuring Set:

- Connect microphone to connector [13]
- Switch [22] to position TALK

By this means, the two way speech connection has been established. It is also possible to setup the complete measuring and speaking configuration in the reverse direction.

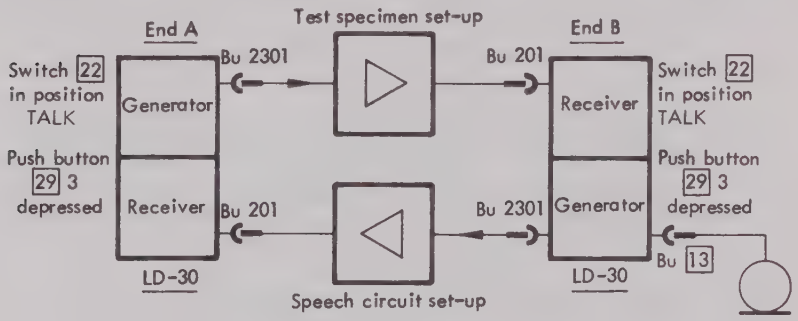

Fig. 2-11 Four wire system fitted with speech circuit

2.7.4.2. Double measurement on four wire systems

Double measurements enable fast testing of a four wire system in about half the usual testing time. If the operator at the far end wants to say something, then it is possible over the speech facility.

The set-up is shown in Fig. 2-12:

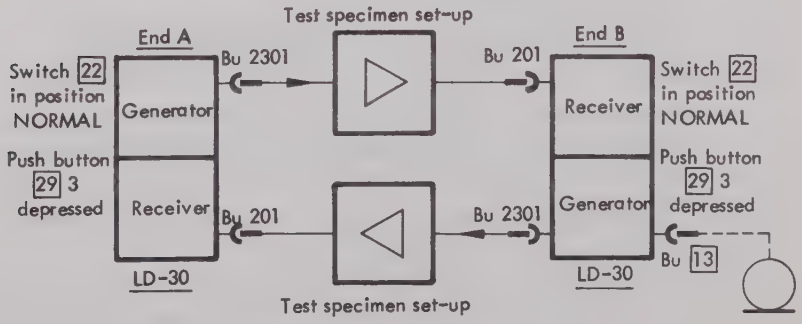

Fig. 2-12 Four wire measurements in parallel operation

The following settings are to be done:

- Push button [29] 3 depressed
- Switch [22] in position NORMAL.

The four wire circuit is now separately tested in the forwards and reverse directions.

The operator at end A wishes to say something to the operator at end B. Thereby the measurement between end A and end B is interrupted, but the measurement from end B to end A retains status.

- Microphone at end A connected to Bu [13]
- Switch [22] switched to position TALK.

End A now speaks and the internal loudspeaker at end B annunciates the information. If now end B wishes to speak in the opposite direction, then a duplex circuit is established, and the measurement is interrupted. A switch-over to the measuring position is simple and fast with switch [22] placed in position NORMAL.

2.8. Further possibilities for applications of the LD-30

2.8.1. Application as Level Measuring Setup

By means of switching off the modulation and carrier change-over, the Measuring Set LD-30 can be used as a normal level measuring setup. For this, switch [22] is placed in position MOD/OFF and push button [31] 5 is depressed. The Generator section delivers a sinusoidal signal in frequency range from 200 Hz to 20 kHz at a level of - 50 dBm to + 10 dBm. The Receiver operates as a wideband level meter in a frequency range of 200 Hz to 20 kHz.

For more exact measurements of variations with frequency, however, it is recommended that the carrier change-over process should once again be used in order to take advantage of the higher resolution available when measuring Δa and the absolute value of attenuation at a discrete frequency be measured (e.g. the band centre).

2.8.2. Application as sweep measuring setup

The Level Measuring Setup LD-30 described in section 2.8.1. can be operated, without additional attachments, as a level and sweep measuring setup. Level and sweep measuring settings are done as previously described.

2.8.3. Measuring Set LD-30 as frequency counter

The Receiver section of the LD-30 is also operable as a frequency counter. It has a resolution, when measuring frequency, of 1 Hz with the use of push button [7] DEC POINT shift. The error limits of the readout are $\pm 5 \times 10^{-3} \pm 1$ Hz at the ambient temperature range + 15 °C to + 35 °C. If results of greater precision are required, then the Measuring Set LD-30 can be fitted with a "Crystal Controlled Time Base" (see section 2.9.3).

2.9. Optional devices

The following described optional devices are only fitted when requested at the time of ordering. However, retrofitting of the optional devices described in sections 2.9.1. to 2.9.6. can be done at any time. Note the listed order numbers given for the various options, and the modifications with alignments are described in Chapter 5 Functional Tests, Maintenance and Miscellaneous. A compilation of all order numbers is located also in Chapter 1 TECHNICAL SPECIFICATIONS.

2.9.1. Remote control of level, measuring frequency and reference frequency

Remote control of level, measuring frequency and reference frequency of an LD-30 located at the far end B can be done at the operating end A with a second LD-30 Measuring Set. For this a set of 3 individual cards, "Remote Control Cards BN 691/11" are needed for installation in the LD-30 located at end B. Thus, this brings about the possibility of using remote control at end A for measuring a path in the direction from end B to end A. See Fig. 2-13.

For the measurements with remote control, the LD-30 at end B is switched at [22] to the position REMOTE. In order to maintain the same remotely controlled level at the output of the Generator at end B, the switch [20] and the potentiometer [5] must be set to 0 dB. If, however, attenuation of the reference signal occurs on the remote control line, then this can be compensated for by means of switch [20] and potentiometer [5]. Verifying the received signal is possible on the meter.

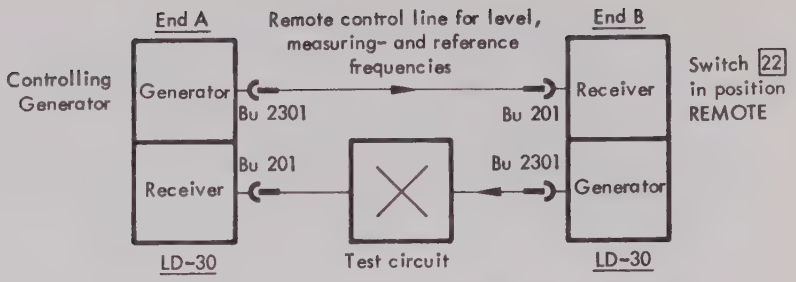

Fig. 2-13 Remotely controlled end-to-end measurement from end B to end A

Further adjustments are not required at end B. Independent of the remote control line characteristics, the measuring and reference frequencies may be adjusted at end A. Remote controlling the level is unaffected by the attenuation frequency distortion of the remote control line because the level in the Receiver at end B is sampled only during the reference cycle.

2.9.2. Dial tone blanking filter

Fitting the additional card "Dial Tone Blanking Filter BN 691/12" permits the LD-30 to reject two dial tones in the frequency range 1.6 to 20 kHz. The combination of two optional values from the series of usually used dial tone frequencies is possible.

The dial tone filters prevent energizing the dial tone receivers in the transmission system, and thereby prevent interrrupting the connection as a result of the measuring signal. The response range of the dial tone filter is $f_{blanked} \pm 150$ Hz.

Each dial tone filter is designated by means of its frequency being labeled on the front panel of the Generator. Before the measurement in made, the desired dial tone filter is selected with push button 28 5 or 28 6 . When the filter is switched IN, the measuring frequency cannot be manually selected at the dial tone blanking frequency, when in swept frequency operation, that frequency is skipped over. Simultaneous use of both filters is permissible when the selected dial tone frequencies plus their response ranges do not cut out needed measuring frequencies.

Attention: The reference frequency may not be located at one of the dial tone blanking frequencies.

2.9.3. Crystal controlled time base

The accuracies given for frequency setting and evaluation in Chapter 1 SPECIFICATIONS may be considerably increased by means of fitting the "Crystal Controlled Time Base (1 MHz Oscillator and frequency divider), BN 691/13". The max. error limit of the frequency readout is $\pm 1 \times 10^{-5}$ when a crystal controlled time-base is used.

In the CCITT Recommendation M.102, the defined frequency shift introduced by a CF circuit is permitted to be a max. of ± 5 Hz. The LD-30 Measuring Set when equipped with a crystal ccntrolled time-base can be used for checking CF circuits to determine if they conform to the max. permissible frequency shift values. For exact measurements of frequency shift, however, a frequency shift measuring set should be used, e.g. FVM-1 or DLM-1 from Wandel u. Goltermann.

2.9.4. D.C. loop-holding circuit for measurements over subscribers' telephone lines

When measuring over subscribers' lines, the LD-30 many times instead of the subscriber's telephone set is connected into the circuit. But the d.c. loop-holding current flowing from the "a" conductor to the "b" conductor must not be interrupted during the change-over from the subscriber's telephone set to the Generator output or the Receiver input. Thereby, the Generator output or the Receiver input must each have a "D.C. loop-holding circuit BN 691/14" connected in parallel so as to be load the d.c. loop.

2.9.5. Low-pass filter

A 10 kHz low-pass filter is available for rejecting the 16 kHz metering pulses and for reducing noise interference. The low-pass filter is fitted internally to the Measuring Set LD-30. Designation for ordering the required additional card is: "Low-pass filter, BN 691/15".

2.9.6. Z_{out} network

A different version of the LD-30 Measuring Set is offered by the network card with other input and output impedances. Changing-over of the impedances is done in

common for the Generator output and Receiver input on the back panel of the Set. The selected impedance is indicated by means of an LED on the front panel. The following impedance combinations are possible:
600/150 Ω, 600/400 Ω, 600/800 Ω, or 600/900 Ω.

3. TECHNICAL INSTRUCTIONS

3.1. Determining the error limits of group delay distortion

A high-pass filter for suppressing the noise from selectors is located in the input circuit of the Receiver. Therefore, group delay distortion measurements introduce an additional error which varies inversely with the measuring frequency. This error becomes larger as the measuring frequency goes lower. The guaranteed values given in Section 1.2. are verifiable by the user when a short circuit measurement is made. He obtains, thereby, a correction curve for the errors in his own measuring set, and the measured results can be corrected from values on the curve.

The variation of group delay distortion with measuring frequency is extracted according to the measuring configuration in Fig. 3-1.

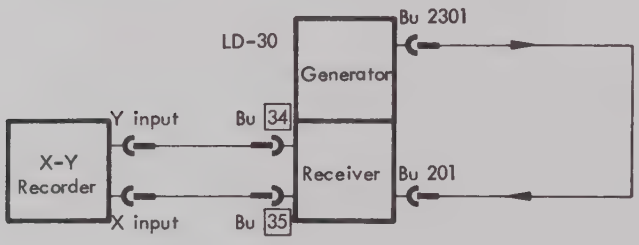

Fig. 3-1 Measuring configuration for recording the variations with frequency of measurement errors related to indications of group delay distortion and attenuation frequency distortion.

Since the errors remain constant at measuring frequencies higher than 1 kHz, the swept frequency range is sufficient from 200 Hz to 2 kHz. With a higher send level a greater signal-to-noise ratio is obtained, and therewith an unambiguous curve of the measured results.

The typical zero point- and group delay indication- error variation with frequency of an LD-30 Measuring Set operating under the given conditions is illustrated in Fig. 3-2.

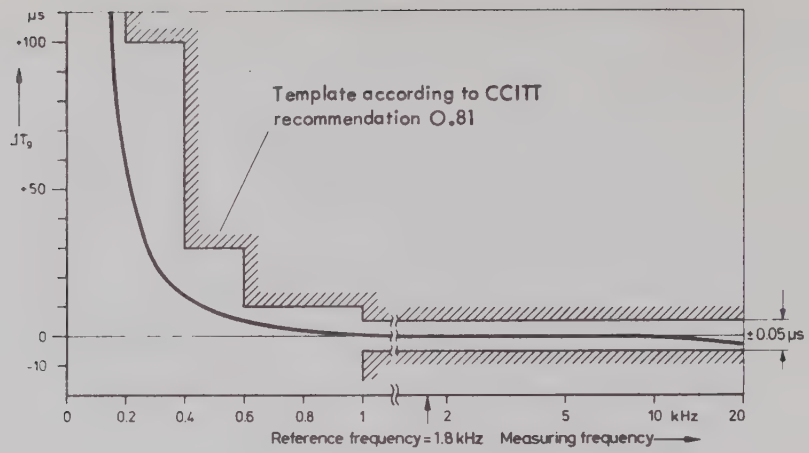

Fig. 3-2 Typical zero point- and group delay indication- error variation with frequency; referred to 1.8 kHz.

3.2. Determining the error limits of the attenuation frequency distortion

The error limits of the attenuation frequency distortion given in the guaranteed specifications can be verified by the user, himself. The minor expenditure for measuring makes it worthwhile to determine the self-introduced error.

The measuring configuration is set-up as for Fig. 3-1.

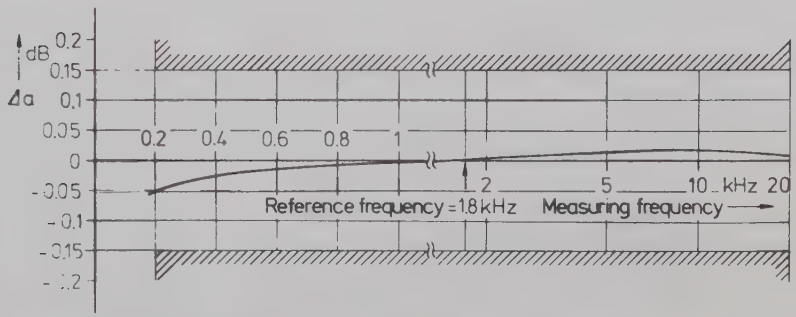

Fig. 3-3 Typical attenuation indication error variation with frequency; referred to 1.8 kHz.

The following values for adjustments are required:

Send level	0 dBm
Reference frequency	1.8 kHz
Measuring range for	± 0.15 dB
Sweep rate	10 Hz/s
Readings	fast

The typical attenuation frequency distortion indication error is illustrated in Fig. 3-3.

Attention: Technical instructions for remote control, retransmission, X-Y recorder and speech operation are not included here because detailed information is given in Chapter 2.

4. FUNCTIONS AND CHARACTERISTICS

4.1. Measuring procedure

The complex transfer function $\vec{g}$ of any two port network is written with the expression

$$\vec{g} = a(\omega) + j\,b(\omega).$$

Therefore, $a(\omega)$ represents the attenuation behaviour and $b(\omega)$ the phase behaviour.

Since telephone circuits previously had been intended exclusively for transmitting speech, the corresponding transmission paths were installed only for the requirements which conformed with the importance of intelligible speech. The human ear judges the intelligibility according to the spectral energy distribution of the incoming signal, thus the wave shape of the signal has no significance. Now, with transmission, the spectral energy distribution of any signal is affected by the attenuation behaviour of the path, but in contrast, the signal wave shape is also affected by the phase shift. However, the frequency behaviour of a telephone channel was, in the past described with sufficient accuracy through the statement for the attenuation curve. This information is not sufficient when telephone channels are used for data transmissions. Here, the signal is a sequence of individual rectangular shaped pulses applied to the input of the send modulator, and after being processed in the receive demodulator, the pulses should be available with as little falsification as possible.

This, however, is only assured if the response behaviour of the transmission system which varies with attenuation as well as with phase is taken into consideration.

Phase measurements over telphone lines introduce problems because the voltage applied to the input is not the same after transmission and is not available as reference voltage at the output of the transmission path. Additionally, minor differences of the carrier frequencies can falsify the measurement because of frequency shift (up to 10 Hz) between input and output of the carrier frequency system. For this reason, the criterion of phase behaviour is not the phase itself, but its first derivative with respect to circuit frequency , the group delay $\Delta\tau g$ is used.

The basis for determining the group delay is formed by the Nyquist method with which the phase shift of an envelope is measured after an amplitude modulated oscillating

signal is passed through the test specimen. This phase shift is with a sufficiently low modulating frequency a direct measure of the group delay of a test specimen. By means of varying the carrier frequency, an interesting quantity, the group delay fluctuation with frequency can be obtained.

In the original form of the measuring procedure, through demodulation of the input voltage as well as the output of the test specimen, two modulation voltages were recovered, and their phase difference was measured. This phase difference is proportional to the group delay of the test specimen. In practice, however, the main interest is group delay difference and this is measured by comparing the variation of group delay with frequency to that of the delay at an average transmission frequency. These fluctuations are mostly smaller by an order of magnitude than the absolute group delay, so the group delay variation through difference formation out of larger magnitudes can be maintained with less accuracy. Furthermore, an end-to-end measurement whose sender and receiver are separately located cannot be done without other equipment:

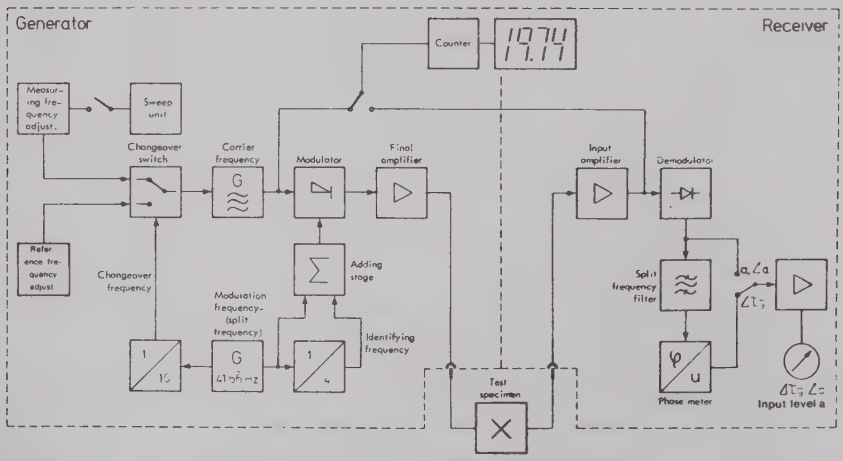

Fig. 4-1 Simplified block diagram of the LD-30 Measuring Set.

This disadvantage is prevented by the measuring procedure used in the LD-30 Measuring Set. The simplified block diagram of the Measuring Set permits easier

understanding of the operating principle described as follows:
Two carrier frequencies produced by the Generator are periodically sampled at 4.166 Hz, and then the modulation (split) frequency of 41.66 Hz is applied for continuous amplitude modulation. One of the two carrier frequencies is varied in the frequency range of interest (measuring frequency) whereby the other is fixed tuned to an optional value in the transmission range of the test specimen (reference frequency). For identifying the reference cycle, an additional modulating signal of 166.66 Hz is applied to the reference carrier during the last fifth of the interval allocated for the reference carrier.

If the measuring signal is fed via a test specimen, and two different group delays are produced for the two carrier frequencies, then the signal's envelope exhibits a phase jump at the output of the test specimen.

In the Receiver a zero-phase alignment is made during every reference interval. During any measuring interval the phase meter obtains a result which corresponds to the group delay difference between the measuring frequency and the reference frequency. The periodically repeated zero-phase alignment prevents drift and time variant instability.

Corresponding to the different attenuation behaviour of the test specimen, the measuring signal and the reference signal exhibit different amplitudes at the output of the test specimen . Evaluation is made so the attenuation difference is indicated as referred to the reference signal.

4.2. Generator

The Generator produces a send signal defined according to CCITT Recommendation O.81. The send signal is repeated in Fig. 4-2. In addition to the send signal, Fig. 4-2 contains the individual signals.
The functional operation of the Generator is explained by means of the fold-out block diagram in the Appendix.

Essentially, the Generator comprises 4 modular units:
- Carrier frequency generation and control (25)
- Modulation frequency generation (24) (auxiliary frequency generation)

- Modular and final amplifier (23)
- Frequency counter (26)

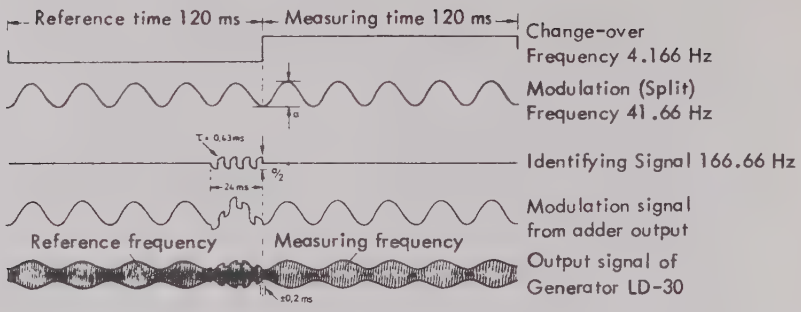

Fig. 4-2 Signal plan of the Generator

4.2.1. Carrier frequency generator (25)

The heart of the "Carrier frequency generator (25) " is a triangular wave generator (voltage to frequency converter). A sinusoidal shaper follows and converts the triangular wave into a sinusoidal wave. The voltages offered from the triangular wave generator are produced by two d.c. voltage stabilizers for the purpose of conversion to measuring carrier frequency and reference carrier frequency. Both d.c. voltages are applied to the triangular wave generator via the carrier frequency change-over switch which changes-over at 4.166 Hz derived from a master oscillator in the Measuring Set.

Opening the control loop of the d.c. controller circuit, used for adjusting the measuring frequency, is permitted by means of the controller circuit switch. Thus, instead of the controller circuit output being fed to the carrier frequency change-over switch, d.c. voltages are fed in for adjusting the upper and lower sweep limits or, once again, the reference frequency.

The reference frequency, the upper and the lower frequencies are adjusted by means of the thumb-wheel switches [25] , [1] and [16]. For the measuring frequency, potentiometer [4] is used for adjustment.

Also the measuring frequency has a parallel connection to a d.c. amplifier whose

output is a d.c. voltage proportional to the measuring frequency. This d.c. output is applied as a deflection voltage at the X-Y recorder output Bu [35] .

Through depressing push button [31] 1 for calibrating an X-Y recorder, the X-output SENDER connector [35] is placed at zero potential.

4.2.2. Modulation frequency generator (24)

The modular unit "Modulation frequency generator (24) " contains a master oscillator for producing the modulation frequency of f = 41.66 Hz. By means of frequency division and multiplication, phase locked derivations for the change-over frequency 4.166 Hz, the identifying signal 166.66 Hz and the gate time 100 ms for the frequency counter are obtained. In the adder stage during the last fifth of the reference interval, the modulation frequency having been shifted by 90° is added with the identifying frequency.

4.2.3. Modulator and final amplifier (23)

The amplitude modulation of the carrier wave by the modulation wave takes place in the modular unit "Modulator and final amplifier (23) ".

In the modulator, the modulation signal is beat with a defined direct current whereby the modulation alternating current amplitude is fixed at a ratio of 1 : 2.5 (modulation depth = 0.4).

The current mixture is fed to modulator II where the actual amplitude modulation of the carrier signal takes place. The d.c. and the modulating alternating current are suppressed, and at the output of modulator II, only the carrier wave f_T appears along with both side bands $f_T - f_M$ and $f_T + f_M$.

Modulator II is followed by the coarse attenuator for level [20] , the fine attenuator [5] and the final amplifier which conditions the output power so as to be available for further use.

The output transformer enables the galvanic separation of equipment circuitry and the output, balanced and floating. The absence of return loss from the connected test specimen is brought about by the special matrix for output impedance.

When push button [29] 1 is depressed, the circuit of the speech facility enables reception of speech signals through the output connector. When the Generator is in send mode, the incoming speech signal is routed back through the output transformer to the final stage at transistor T 2316. Amplification of the speech signal is introduced by transistor T 2316 and is fed via switch [22] to the speech facility. The send signal is compensated with P 2313, R 23117 and R 23112.

4.2.4. Frequency counter (26)

The four digit frequency readout takes place with the aid of the modular unit "Frequency counter (26) ".

The frequency counter is provided with a gate time of 100 ms only during the measuring cycle, and the modulation frequency is the source of the gating signal. Thus, only during this time can there be readout of the frequency produced at the triangular wave generator. The (10 X) frequency multiplier first multiplies the measuring frequency by 10 before it is fed to the frequency counter. Push button [7] permits raising the resolution of the frequency readout.

With depression of push button [32] , only the reference frequency is indicated during the measuring and reference cycles.

Slide switch [8] changes-over the frequency counter for reading out either the send or the receive frequency. The accuracy of the frequency counter depends on the accuracy of the modulation frequency oscillator. For attaining a higher accuracy, a "Crystal controlled time-base (BN 615/13)" can be fitted if desired.

4.3. Receiver

In the Receiver of the LD-30, the modulation envelope's phase and attenuation jumps caused by the test specimen are evaluated. The Receiver is made up from five main groups (see fold-out block diagram in Appendix):

- Input amplifier (2)
- Evaluation circuit (4)
- Indicator amplifier (3)
- Frequency evaluation (5)
- Speech facility (6)

4.3.1. Input amplifier (2)

The input of the receiver is balanced and floating. The combination of the carrier demodulator and the input amplifier forms a unit. It operates without an input attenuator over the complete receive level range of - 50 dBm to + 10 dBm.

The residual carrier at double frequency resulting from the demodulation process is suppressed in the carrier frequency filter. The output signal from the filter is made up of a d.c. proportional to the carrier level and a superimposed modulation (split frequency and identifying signal). The logarithmizer stage which follows converts the carrier current into a voltage proportional to the logarithm of the input level (1 V/10 dB).

4.3.2. Evaluation circuit (4)

The functions of group delay measurement and level or attenuation measurements are separated by means of the "Evaluation circuit (4) ".

As a result of the logarithmic operation, the modulation amplitude is independent of the input level. It is selectively amplified and limited in the split frequency filter whose output is a square wave voltage containing the phase jump caused by the group delay difference of the test specimen. The square wave voltage is used for synchronizing the multivibrator which generates the split frequency pulses. When the input signal is not modulated, i.e. operation as level meter, the multivibrator is free-running.

In the identification channel, the identification pulse which at the time first toggled the 198 ms monostable is recovered from the signal coming from the logarithmizer. After this interval of time delay, the pulse stage is triggered. The following AND gate generates a setting pulse which defines the position of measuring and reference clocks, and thereby the clock for all other control signals.

The 41.66 Hz band-stop filter output is a d.c. voltage corresponding to the average value of the carrier level. This d.c. voltage is then filtered by a 13 Hz low-pass filter. Thereupon rejection of the residual modulation frequencies (41.66 Hz and 166.66 Hz) is sufficient for the succeeding evaluation in the "Indicator amplifier (3)".

4.3.3. Indicator amplifier (3)

The "Indicator amplifier (3)" evaluates the signals coming into it and processes them for indication. Therewith, the measured results - group delay distortion, attenuation frequency distortion or level - are possible only at the time of the evaluation. The indicator buffer-store takes over the measured result when the sampling signal is intercepted from the indicator amplifier. The meter and the Y output are held at a constant voltage which corresponds to the measured result. When push button [31] 1 is depressed for calibrating the X-Y recorder, the Y output at connector [34] is placed at zero.

4.3.3.1. Measuring group delay distortion

The 100 ms monostable and the 9 or 4/14 ms delay line are timed for group delay measurements. At the beginning of the measuring or reference cycle, the 100 ms monostable is toggled. After 100 ms, the 9 ms delay line is enabled. If the split frequency signal has no phase jump ($\triangleq \Delta \tau g = 0$ ms), then the time interval is 11 ms from the end of the 109 ms interval to the retoggling of the 100 ms. This is valid for both the measuring cycle as well as the reference cycle. However, if the split frequency signal is subjected to a phase jump, then the time intervals for retroggling the monostable are not equal in the measuring cycle and the reference cycle.

The clock generator derives from these time intervals the signals "Charge" and "Discharge". In the indicator amplifier the signals "Charge" and "Discharge" are used to charge with constant current a capacitor and then to discharge it again. With a group delay difference of 0 ms, the capacitor after being discharged has the same charged status again as at the beginning of the charging process. If a group delay difference is present, then the charging and discharging times also are different, and the capacitor has at the end, according to the algebraic sign of the group delay difference, a positive or negative charge. This charge corresponds to the measured result.

After the measured result is transferred to the indicator buffer store during the sampling time, the capacitor is again discharged. When the measurement range is switched, the magnitude of the capacitor is electronically changed. The maximum measurement range possible is ± 10 ms. The internal group delay basic offset of + 5 ms (switch [11]

enables this offset and it is only possible in the position ± 10 ms). This permits expanding the measuring range to + 15 ms. It is attained through changing the time intervals in the 9 ms delay line (in reference cycle, 4 ms delay, in measuring cycle, 14 ms delay).

4.3.3.2. Measurement of attenuation frequency distortions

The indicator amplifier contains a d.c. voltage, coming from the evaluation circuit (4), and corresponding to the input level.

At the beginning of the reference cycle, the indicator amplifier by means of a "clamping pulse", is clamped to the measuring level. With the following sampling pulse, it takes over the reference level. The indicator amplifier forms the difference between measurement level and reference level and delivers it; to be indicated as an attenuation difference referred to the reference level. The measurement range switch [23] varies the gain in the indicator amplifier.

4.3.3.3. Measurement of input level

Level measurements are possible both with normal operation having carrier changeover between measuring and reference carriers as well as with unmodulated input signals. With normal operation of the Measuring Setup, the level of the measuring carrier is indicated. When push button [32] is depressed, the reference frequency is displayed and the reference level is indicated. Simultaneously with the "clamping signal", the signal "zero keying" coming from the clock generator is delivered to the indicator amplifier. With this signal, the indicator amplifier obtains its reference point for the subsequent difference formation. The reference point accordingly is that defined d.c. voltage corresponding to each selected level measurement range.

During the sampling process, the indicator amplifier takes over from the evaluation circuit (4) a d.c. voltage corresponding to the measuring level and then forms the difference with the reference point. The possible difference provides a reading of ± 10 dBm, the reference point can be varied in 10 dBm increments from – 40 dBm to 0 dBm. If the level of the reference carrier is to be indicated, then the signals "clamp", "sample" and "zero keying" are located in the other cycle.

4.3.4. Frequency evaluation (5)

"Frequency evaluation (5) " enables frequency readout of measuring and reference frequencies with carrier change-over operation, but also other input signals can be displayed.

The illuminated numerals indicate the measuring frequency provided that [32] is not depressed. A portion of the input signal is routed to the automatic control amplifier where it is brought to a constant value and converted to a square wave signal. The differential flip-flop compares the frequency ($f_{nominal}$) coming from the auto. control amplifier with the frequency (f_{real}) coming from a multivibrator.

The output signals of the differential flip-flop are converted by a charging circuit into d.c. voltage which varies the frequency of a multivibrator until the requisite $f_{real} = 10 \times f_{nominal}$ is achieved.

The frequency f_{real} of the multivibrator causes the frequency counter (with read-out buffer store and decoder) to display the frequency, and additionally provides at the output of a discriminator a d.c. voltage proportional to frequency. This is intended for the X deflection of an X-Y recorder. After push button [31] 1 is de-pressed for calibrating a recorder, the X output is placed at zero.

Synchronization of the internal frequency generator with the measuring frequency applied to the input is done in the measuring cycle. The gate time of 100 ms for the frequency counter occurs during the reference cycle, so the measuring frequency is displayed during the reference cycle. The gate time of 100 ms is delivered from the modulation frequency section (24) of the Generator. In order to increase the accuracy of the frequency readout, the gate time can be obtained also if requested by means of a retrofitted "Crystal controlled time base (BN 691/13)".

The LD-30 Measuring Set uses identical frequency counters with readouts in both Generator as well as Receiver.

4.3.5. Speech facility (6)

The "Speech facility (6) " enables the addition of speech connections on two wire or four wire systems. An internal loudspeaker reproduces a received speech signal in all operating modes.

In positions two wire output at switch [29] 1 and operating mode NORMAL at switch [22], the LD-30 Measuring Set is always ready to receive a speech signal when making end-to-end measurements.

A received speech signal is fed in via the Generator output connector Bu 2301 to transformer Ü 2301 at the output stage T 2316 and then to IC 2308. The simultaneously present Generator signal is compensated (to out of band) over the network P 2313, R 23117 and R 23112. The speech signal is fed over amplifier IC 604 to the loudspeaker for reproduction.

If the push button [29] 1 is depressed for two wire output and measurement mode switch [22] is switched to position TALK, then Bu [24] is parallel to Bu 2301 for the connection of a telephone set.

When operating with loudspeaker and microphone or handset, the connector Bu 2301 is connected to the hybrid transformer Ü 601 and Ü 602, so that the received signal is switched via Bu 2301 to the loudspeaker. With push button [29] 1 depressed, the Receiver remains connected via Bu 201 to the receive section, and thereby is unconditionally ready for operation.

If push button [29] 2 two wire input is depressed and the operating mode TALK is to remain, then Bu [24] is for connecting a telephone set parallel to Bu 201, or with microphone operation, Bu 201 is applied to the hybrid transformer Ü 601 and Ü 602.

The hybrid transformers separate the two signal directions. The incoming speech signal is at Ü 602 at points 7 and 8. It is fed via P 601 through the amplifier IC 604 to the loudspeaker. The speech signal from a microphone is amplified by IC 602 and is fed via Ü 601 points 7 and 8 to the two wire line. The termination of the hybrid transformer is formed by the connected telephone line.

If the loudspeaker is connected to the Receiver input, then an automatic circuit causes the measuring signal to be attenuated for about 1 s with the presence of the incoming speech signal (reduction circuit). The attenuation is internally adjustable for from 30 % to 100 % of the adjusted measuring signal. The speech signal, however, remains as received.

5. FUNKTION CHECKING, MAINTENANC AND GENERAL INFORMATION

5.1. Testing the LD-30 Measuring Set

If it is desired to make a fast determination whether the Measuring Set is functional - e.g. after long term storage in a store room for test sets - a short test can be made.

Information about this test is also given in para. 2.5.1.4.

The following adjustments are necessary:

- Connect Measuring Set to A.C. line
- Switch ON power switch S 101 of LD-30 Measuring Set
- Connection from Generator output Bu 2301 to Receiver input Bu 201
- Adjust the send level 0 dBm with switch [20] and potentiometer [5]
- Adjust measuring frequency and reference frequency to 1.8 kHz
- Depress push button [31] 3 on Receiver
- Measurement range switch for group delay distortion [11] adjusted to ± 1 ms
- Depress push button [6] TEST
- Meter [10] must indicate approx. + 1 ms
- Depress push button [31] 4
- Measurement range switch for attenuation frequency distortion [23] adjusted to ± 1 dB
- Depress push button [6] TEST
- Meter [10] must indicate approx. + 1 dB

5.2. Removal of cabinet panels

Caution: A.C. line voltage plug should be pulled out before maintenance is performed on Measuring Set.

Bottom, cover and side panels are fastened with screw clamps on the back panel of the Measuring Setup. Each panel can be removed after the two corresponding screw clamps have been unscrewed, all panels are pulled away backwards.

5.3. Retrofitting, checking functions, and aligning accessories

Paragraphs 5.3.1. to 5.3.6. offer the user possibilities of in-house modification or retrofitting accessory devices which have been ordered and delivered after the Measuring Set was delivered. Also it is possible to check the functions and do any possible recalibrations, if necessary.

All of the test equipment needed for the verification and recalibration is available normally in any service department. These items are especially mentioned for every section.

When modifications are made, exceptionally careful measures should be taken to prevent damaging any individual components or any printed circuit boards which are to be retrofitted as well as the basic unit itself should not be mishandled.

Before checking the functions or aligning, the Measuring Set plus the added devices should be warmed-up for 10 minutes. All statements in the paragraphs for checking the functions and aligning are referred to room temperature.

The delivered printed circuit boards are provided with identification designators as e 691-AL or 691-7010 ... or with both. These designations are typical for every printed circuit board and are also named in the following paragraphs.

5.3.1. Remote Control Device BN 691/11

The remote control device comprises the printed circuit boards:
Remote control of measuring frequency
Buffer store for remote control of level
Reference frequency discriminator.

Adding the remote control device requires the following preparations:
- pull out power plug
- remove top panel
- remove two screws (one at each side) which fasten upper chassis, and then tip chassis forwards and up so it locks in position at approx. 80° vertical.

5.3.1.1. Remote control of measuring frequency

The printed circuit board has the designation 691-AK , 691-7034 ...

- the circuit board is plugged into the contact pins at the left side (looking from the front panel) on the separately accessible counter card under the tipped-out chassis, and four screws are used for fastening the add-on card.
- The included delivered label "REMOTE CONTROL" is fastened to the front panel at switch 22 by the holes already present. Since a pre-alignment was done at the factory, no alignment is needed after the modification.

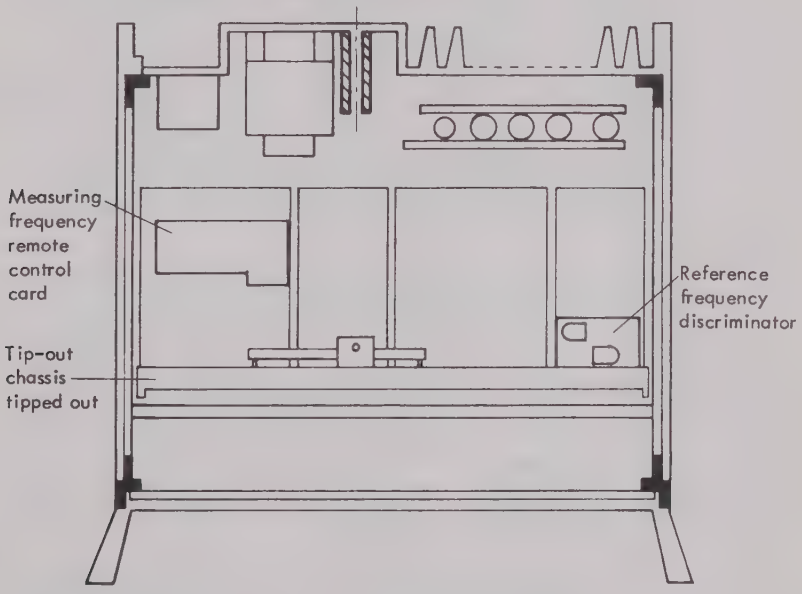

Fig. 5-1 View of LD-30 with tipped-out chassis: information for measuring frequency and reference frequency cards.

5.3.1.2. Buffer store for remote control

The printed circuit has the designation 615-J , 615-7088...

For the fitting, the same preparations as in para. 5.3.1. are necessary, however, the tip-out chassis remains in its horizontal position.

The printed circuit board is plugged-into the contact pins of the input amplifier

card (second printed circuit board from the right when looking at the front panel) on the tip-out chassis, pressed home, and fastened with three screws.

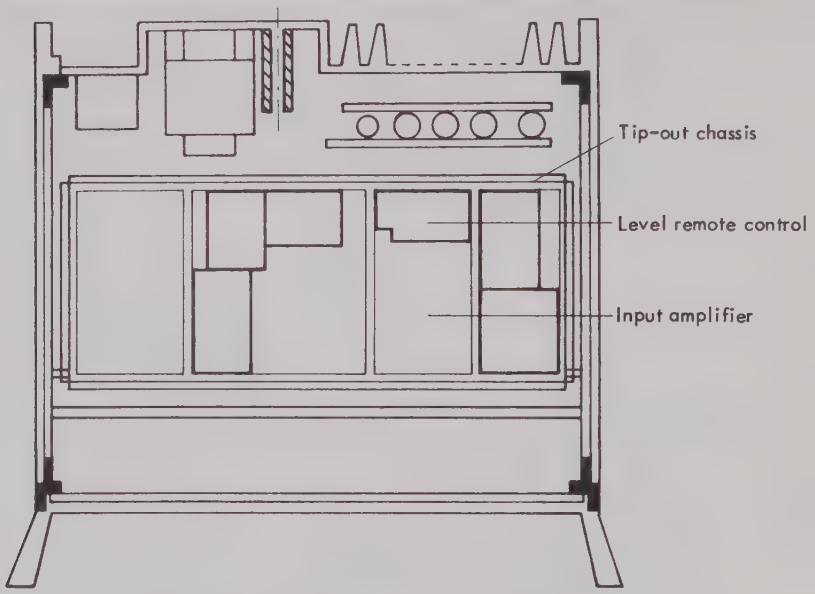

Fig. 5-2 View of LD-30 with tip-out chassis in open position

Checking and aligning

Required test equipment: 1 Measuring Setup LD-30 or LD-3

- Set up the following configuration:

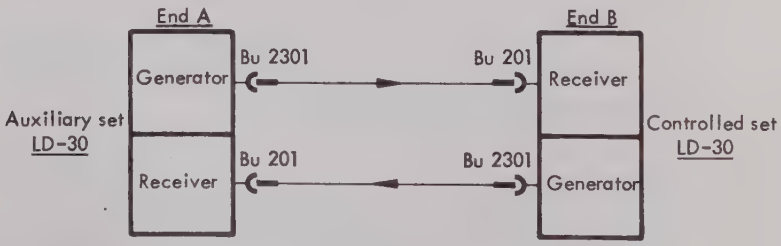

Fig. 5-3 Configuration for checking remote control of level

- Auxiliary Generator in position NORMAL, reference and measuring frequency for instance set to 1.8 kHz

- Send level adjusted at auxiliary Generator so exactly 0 dB is indicated on the Receiver of the controlled set
- Now, at the controlled Generator, place switch [22] in position REMOTE CONTROL
- At the controlled Generator place coarse level and fine level settings in position "0 dBm", this is done because the remotely controlled level could be affected via this switch
- The meter of the auxiliary Receiver should indicate the level "0 dBm" of the controlled Generator
- If the controlled level is not achieved, then the potentiometer P 1102 (500 Ω) at the centre of the printed circuit board should be readjusted so the level is correct
- Coarse level switch of auxiliary Generator set to - 20 dBm, and at the auxiliary Receiver the controlled level should go back to - 20 dBm.
- After the Set has been checked and aligned the tip-out chassis should be re-fastened, and the top panel should be replaced.

5.3.1.3. Reference frequency discriminator

The printed circuit board has the designation [615-K], 615-7009...

For the fitting, the same preparations as in para. 5.3.1. are necessary.

- The printed circuit board is plugged into the contact pins on the right side (looking from the front panel) underneath the tip-out chassis, pressed home, and fastened with three screws.

When mounting the reference frequency discriminator card, Fig. 5-1 should be observed.

Checking and aligning

Required test equipment: a second LD-30 Measuring Set or LDS-3 as auxiliary generator.

- Set up the following configuration:

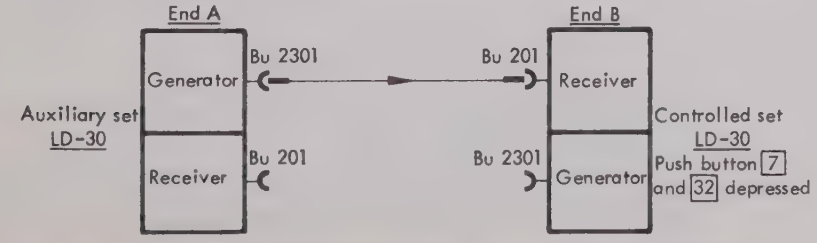

Fig. 5-4 Configuration for checking the remote control of reference frequency

- At the controlled set, place switch [22] in position REMOTE CONTROL
- At the auxiliary Generator, place switch [22] in position MOD OFF (continuous signal without modulation)
- Set 0 dBm send level at auxiliary generator
- Switch [14] for sweep rate of e.g. 10 Hz/s and push button [28] 3 for single shot sweep. Set upper sweep limit to 19.9 kHz, and with potentiometer [2] align at 20 kHz ± 5 Hz. Lower sweep limit is set or aligned at 400 Hz ± 2 Hz.
- At f = 20 kHz (upper sweep limit at auxiliary Generator) potentiometer P 1202 (250 Ω) which is located on the add-on printed circuit board should be so adjusted if required, that at the controlled Generator also 20 kHz with depressed push buttons [7] (decimal point) and [27] (reference signal) is readout.
- Thereupon at f = 400 Hz, (lower sweep limit at auxiliary Generator) with potentiometer P 1201 (5kΩ) on the circuit board added-on in the Receiver should be adjusted, if required, to 400 Hz.
- After checking and alignment, the chassis should be lifted upwards, tip-out catch released, and chassis tipped back to original position and fastened. Replace top panel.

5.3.2. Dial tone blanking filter BN 691/12

The printed circuit board, ordered and delivered afterwards, has the designation [691-AC] , 691-7035...

Retrofitting:

- Remove the bottom panel from the Measuring Set
- Printed circuit board "Dial Tone Blanking" is placed on projecting contact pins on the counter card and pressed home (see Fig. 5-5), the unconnected wire which is fastened to the mother board by means of a cable clamp and the end with the AMP plug is plugged into the free contact on the printed circuit board "Dial Tone Blanking".
- Fasten "Dial Tone Blanking" circuit board with four screws
- Fasten label onto front panel by plugging into holes prepared for this purpose above push buttons [28] 5 and [28] 6.

Check functions of the insertion points (frequency jump) of the dial tone blanking No measuring equipment is required for checking the functions.

Push buttons [28] 5 and [28] 6 permit selecting two of the blanked frequencies determined at the time of ordering.

- One dial tone blanking filter is selected with push button [28] 5 (lower frequency) or [28] 6 (higher frequency)
- Measuring frequency range independent of the inbuilt dial tone blanking frequency is selected via push button [28] 1 (200 Hz to 4 kHz) or [28] 2 (200 Hz to 20 kHz)
- Measuring frequency tuned with potentiometer [4] to higher frequencies. Check frequency with counter readout [9] when switch [8] is placed in position SENDER.

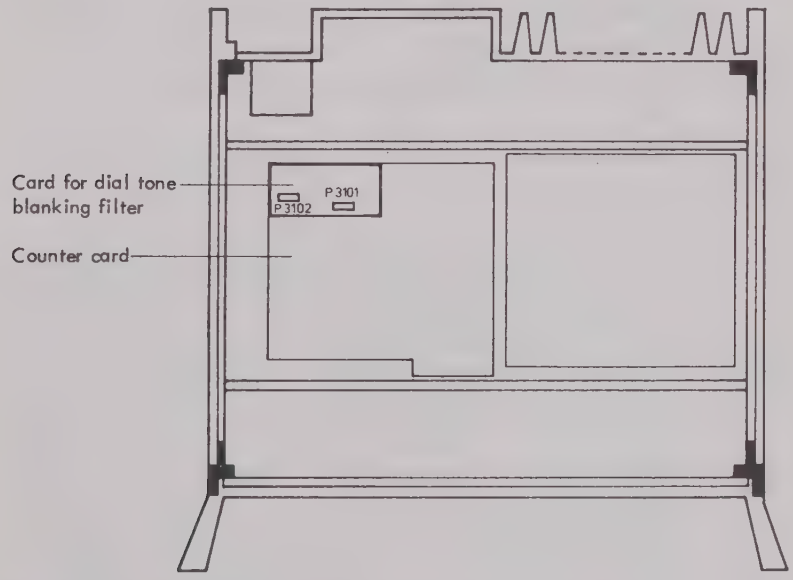

Fig. 5-5 Bottom view of Set showing mounting of dial tone blanking filter

- At measuring frequency

$f_{M1} = f_{Tbf}$ - (150 Hz to 180 Hz) these must jump to

$f_{M2} = f_{Tbf}$ + (150 Hz to 180 Hz)

Example: Nominal frequency of dial tone blanking filter f_{Tbf} = 2280 Hz

f_{M1} = 2280 - (150 Hz to 180 Hz) = 2100 Hz to 2130 Hz

f_{M2} = 2280 + (150 Hz to 180 Hz) = 2430 Hz to 2460 Hz

- the measuring frequency must jump from between 2100 Hz and 2130 Hz to between 2430 Hz and 2460 Hz.

- Repeat checking procedure but with other dial tone blocking filter.

If the insertion point for a dial tone blanking filter is located outside the stated range (f_{Tbf} - 150 Hz to 180 Hz), then a new alignment is necessary.

Alignment of the insertion point (frequency jump) of the dial tone blanking frequency:

- Switch out dial tone blanking filters by means of push buttons [28] 5 and [28] 6.
- Measuring frequency adjusted to $f_M = f_{Tbf}$ - 150 Hz (e.g. f = 2280 Hz - 150 Hz = 2130 Hz).
- Push button [28] 5 or [28] 6 depressed to switch in respective tone blanking filter.
- With alignment potentiometer P 3101 (push button [28] 6 is coordinated with this) or P 3102 (push button [28] 5 is coordinated with this) on printed circuit board "Dial Tone Blanking", adjust the insertion point (frequency jump) $f = f_{Tbf}$ - 150 Hz. Since the insertion point is subject to hysteresis, the insertion point is always adjusted by rotating the potentiometer shaft to the left. Therefore, if the insertion point is located more than 180 Hz under the nominal frequency of the dial tone blanking filter, the respective alignment potentiometer should be rotated fully right to the stop, and then rotated left to adjust the insertion point (see Fig. 5-5).
- Repeat alignment procedure if necessary for the other dial tone blanking filter
- Checking procedure - as described previously - should be done
- After checking and aligning Measuring Set, replace cover panel again.

Notice: The dial tone frequency blanking filters should be ordered according to the actual need of the customer. It is not possible for the customers later to change the filter frequency.

5.3.3. Crystal controlled time base BN 691/13

The crystal controlled time base is comprised of the printed circuit boards "1 MHz crystal oscillator" and "Frequency divider".

The designations of the printed circuit boards are:

1 MHz Crystal oscillator: 615-L 615-7010...

Frequency divider: 615-M 615-7011...

Retrofitting:

- Remove top panel
- Each of the two metalized covers of both boxes on the tip-out chassis should be pried off with a screw driver (see Fig. 5-6)
- Printed circuit board "Frequency divider" in the left box, the printed circuit "1 MHz crystal controlled oscillator" in the right box. Both printed circuits should be placed on their appropriate contact pins and pressed home, and each should be fastened with 4 screws. Then the covers should be replaced on the boxes.
- Check the functioning as follows:

Checking the functions after addition of the crystal controlled-time base.

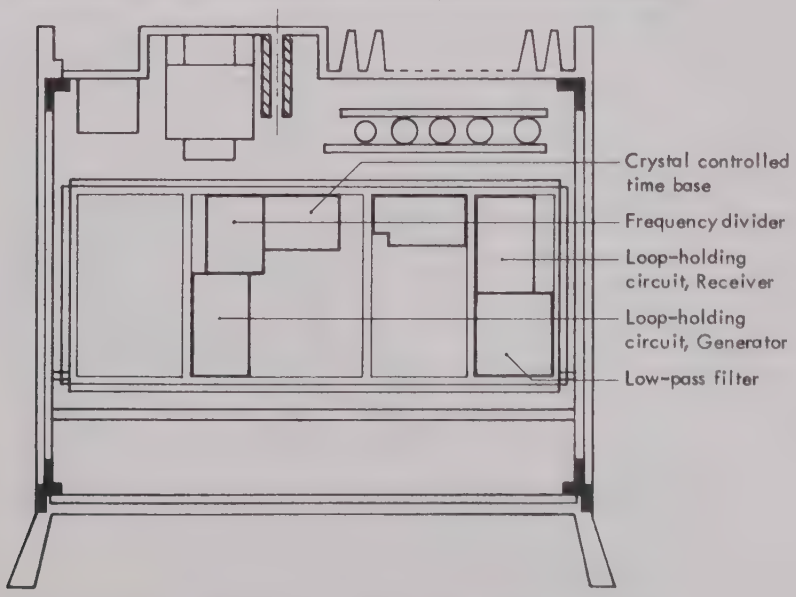

Fig. 5-6 View of Measuring Set looking at tip-out chassis (in tipped-out position) for mounting of crystal controlled time base, frequency divider card, the loop-holding circuit and the low-pass filter.

Required test equipment:

1 frequency counter with period measuring capability, e.g. FZ-4 from Wandel u. Goltermann.

With the box cover removed the divider frequency of 41.66 Hz = 240 000 µs ± 2.4 µs should be verified from point 15 to point 16 on the frequency divider board, and if incorrect should be retuned with C 1302 in the "1 MHz crystal oscillator". After concluding the check the box cover is replaced, and the top panel of the cabinet is replaced.

5.3.4. D.C. loop-holding circuit, BN 691/14

For one LD-30 two circuit boards "D.C. loop-holding circuit" are necessary. The circuit boards are designated: 615-N, 615-7012...

Retrofitting:

- Remove top panel from the Measuring Set
- Circuit boards are placed on the two contact pins, seen from above, and fastened with 4 screws. See Fig. 5-6.
- Replace top panel and refasten.

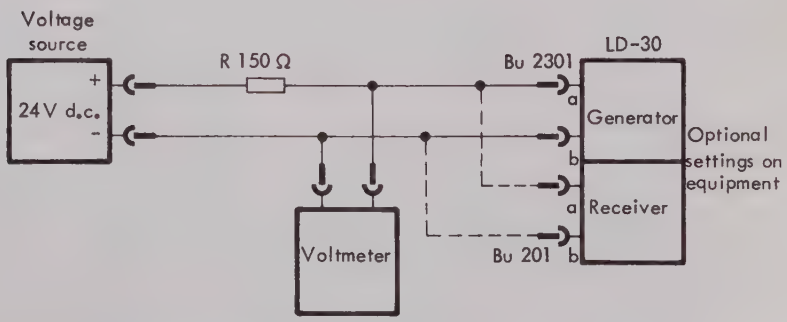

Fig. 5-7 Configuration for checking the functions of the D.C. loop-holding circuit.

Checking the functions:

This checking procedure is valid for the Generator section and the Receive section of the LD-30 measuring set.

Required test equipment:

1 d.c. voltage source 24 V

1 d.c. voltmeter or digital voltmeter

1 resistor, 150 Ω at 2 W

After the measuring configuration is set up, the d.c. voltage indicated on the voltmeter should be between 9 V and 13.5 V.

Note : The voltage slowly swings to the correct value (approx. 45 s). Thereupon, apply voltage to Bu 201 and repeat the measuring procedure. After conclusion of checking measurements, replace top panel on Measuring Set.

5.3.5. Low-pass filter, BN 691/15

The low-pass filter comprises one printed circuit board designated 691-H, 691-7007...

Retrofitting:

- Remove top panel from the Measuring Set

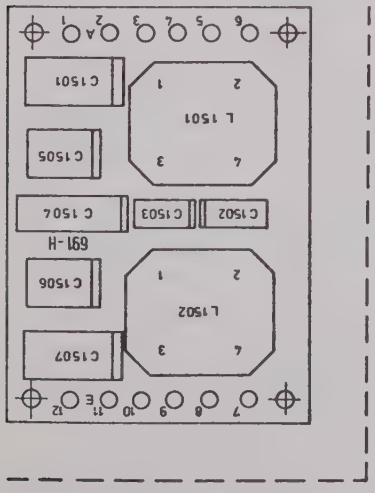

Fig. 5-8 a Operating mode 1

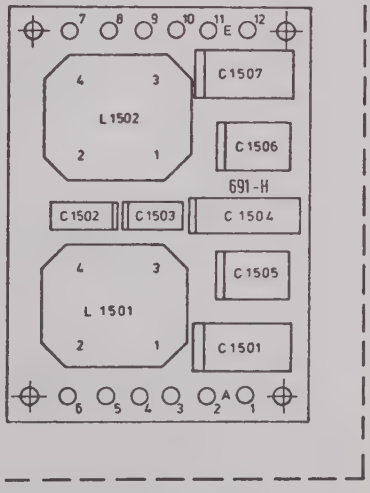

Fig. 5-8 b Operating mode 2

- At the right front of the tip-out chassis, the short circuit board is removed. The free contact pins serve as contacts for the low-pass filter circuit board. See Fig. 5-6
- Circuit board is pressed home and fastened with 4 screws.

Note : The low-pass filter has two possibilities of operation:

Operating mode 1 : Low-pass filter has no effect
The printed circuit board is mounted according to Fig. 5-8 a, thus the low-pass filter is short circuited.

Operating mode 2 : Low-pass filter is connected when the printed circuit board is mounted according to Fig. 5-8 b.

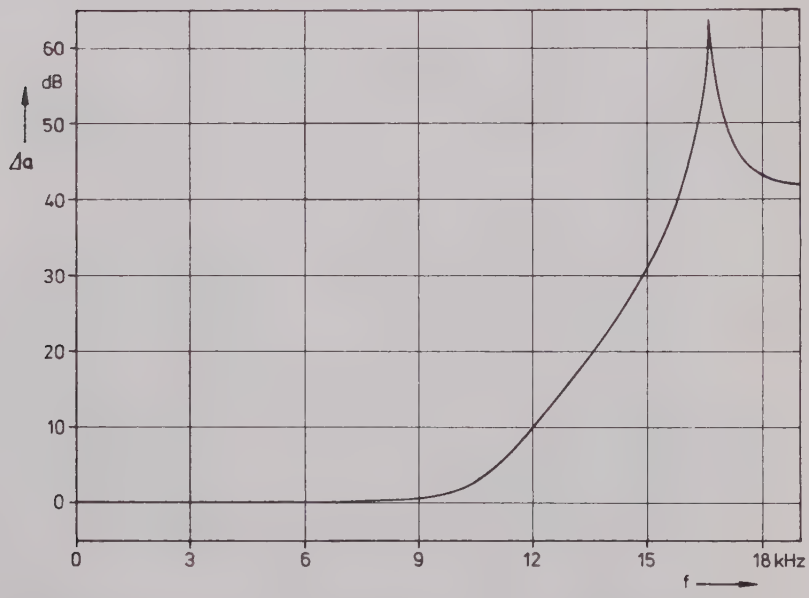

Fig. 5-9 Attenuation curve of low-pass filter when short-circuit measurement is made

After mounting the circuit board, the top panel is replaced.

Checking the functions:

In order to determine whether the low-pass filter is switched in, a short-circuit measurement is made at the LD-30 Measuring Set.

- Generator output and Receiver input are connected together
- Send and Receive levels adjusted to be 0 dBm as well as measuring range LEVEL is selected
- Push button [28] 2 is used to select the measuring frequency range 200 Hz to 20 kHz
- Adjustment of the sweep limits below 200 Hz and above 20 kHz and the corresponding sweep rate e.g. 50 Hz/s with single shot sweep ⌐
- According to the arrangement of the low-pass filter, the meter indicates either an attenuation curve as in Fig. 5-9 or the level remains constant after the push button is depressed to start the sweep.

Switchable Z_{out} / Z_{in} network card

The card is intended for the common change-over of the Generator output and Receiver input impedances between 600 Ω and another value. The different combinations possess the following designations on the printed circuit boards:

Z (out) or (in) network:	600/150 Ω	card [691-AG]
	600/400 Ω	card [691-AH]
	600/800 Ω	card [691-O]
	600/900 Ω	card [691-AJ]

The modification is done with the retrofitting instructions.

Retrofitting:

- Remove top and bottom panels
- Loosen tip-out chassis and place in locked position, see Fig. 5-10
- Connection plug of current Z_{out}/Z_{in} network card [691-S] is plugged into new switchable p.c. board.
- Current network card removed, thereafter the newly connected card is fastened in
- Extension shaft for switch inserted in plastic bushing already fastened to tip-out chassis and the muff is fastened to the shaft of the switch
- Tip back chassis and fasten
- Remove trimming strips from above and below the front panel, and also unscrew the screws which have thus been exposed so as unfasten front panel (12 screws)

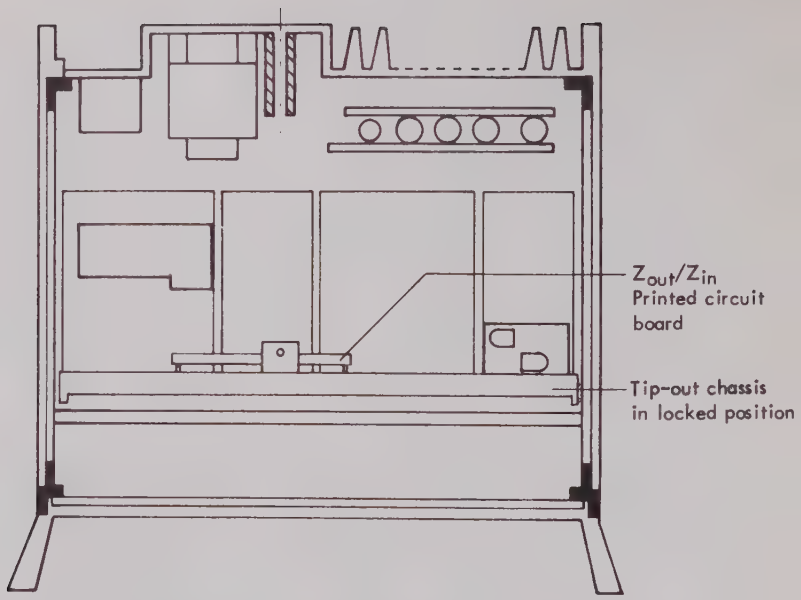

Fig. 5-10 Front view (from front panel) of opened out tip-out chassis with Z_{out}/Z_{in} printed circuit board

- Complete front panel is pulled forwards.
  Lettered plate Z = 600 Ω is pulled away forwards, and the holes for the LEDs are now visible, new lettered plate with two Z values put on proper place.
- LED printed circuit board mounted from the back so the two diodes are placed to be visible through the holes.
- From the wiring harness at the light indicator [691-X], see Fig. 5-11, the free wire is soldered to point 1 of p.c.b. [691-W].

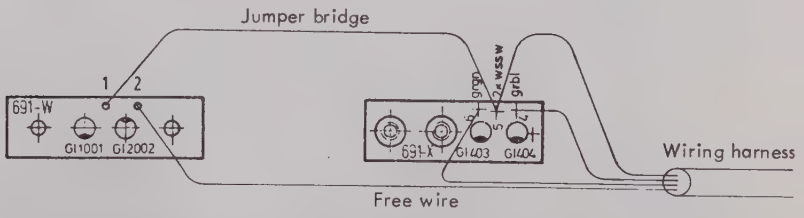

Fig. 5-11 Connections for Z_{out}/Z_{in} light indication at printed circuit board [691-W] and p.c.b. [691-X]

- Jumper bridge (provided) connects point 1 of p.c.b. 691-W with chassis ground at p.c.b. 691-X.
- Fit front panel back in place and refasten

Checking functions: Z_{out}/Z_{in} change-over is valid for Generator and Receiver.

Required test equipment: Ohmmeter

- Ohmmeter connected to Bu 201 or Bu 2301
- Z_{out}/Z_{in} switch located on back panel is changed-over by means of a screw driver, and the ohmmeter is used to verify the correctly illuminated value of LED. If the LEDs are not correctly coordinated with the Z_{out}/Z_{in}, then the p.c.b. 691-W should be rotated 180°.

After concluding the checks, replace trimming strips and top and bottom panels.

5.4. Changing fuses

The a.c. line fuse is accessible on the back panel of the LD-30 Measuring Set. After unscrewing the cap of the fuse holder, the fuse element can be exchanged. Fuse for voltages 220 V, 227 V, 235 V is 0.63 A slow-blow, and for 110 V, 117 V, 127 V is 1.25 A slow-blow.

5.5. Mounting in a 19" rack

The dimensions of the Measuring Set correspond to the American standard "ASA C 83.9 Rack and Front Panels" (or DIN-Norm 41 494). Therewith, the set is suitable for mounting in 19" racks, and only the front panel dimensions need be changed by means of changing the side pieces of the frame around the case.

First the two side panels must be removed (see para. 5.2.). Then the side pieces of the case frame are removed after unscrewing the two screws for each side piece. The side pieces are replaced with one set of 19" mounting brackets, order number BN 556/3.

The foot pieces and guide studs can be detached after removing the cover and bottom panel. The cover, bottom and side panels thus have been prepared for remounting

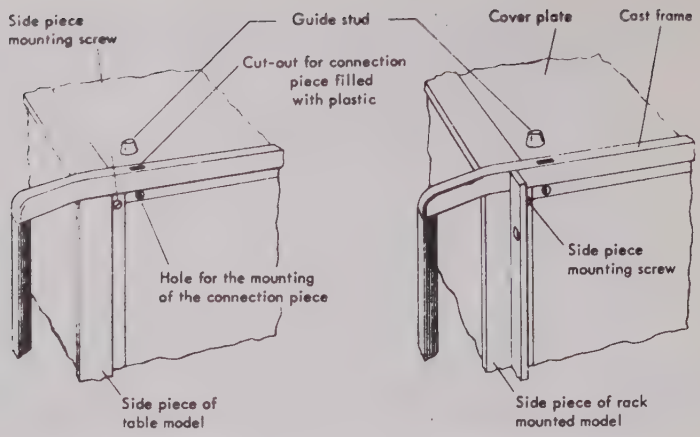
Side piece mounting screw
Guide stud
Cut-out for connection piece filled with plastic
Cover plate
Cast frame
Hole for the mounting of the connection piece
Side piece mounting screw
Side piece of table model
Side piece of rack mounted model

Fig. 5-12 Modification of the bench model for 19" rack mounting

5.6. Joining of several instruments

The new cabinet conception allows the mounting of several Sets one above the other. These sets are firmly mounted together by means of 4 special connection pieces with the order number 00.0400.06/5.

To do this, it is necessary to remove the top panel of the lower instrument and the lower panel of the upper instrument as well as the side panels of both. The small plastic pieces in the frame cut-outs are now pushed out. This is valid both for the four cut-outs of the upper frame and the four cut-outs of the lower frame.

The four connection pieces are placed into the cut-outs of the lower instrument as shown in Fig. 5-13 and are screwed firmly into place. After removing the guide studs from the cover and the foot pieces from the lower panel, both panels should be replaced.

The sets are now placed one above the other so that the connection pieces mounted in the frame of the lower instrument pass through the frame cut-outs of the upper instrument. After firmly screwing the upper instrument to the connection pieces, the side panels should be replaced.

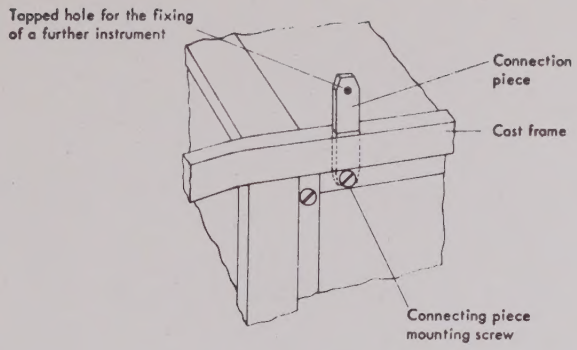

Fig. 5-13 Inserting the connection pieces for the mounting of several measuring sets on one another

5.7. Shipping information

A safe, damage free shipment of the Measuring Set is only assured if correctly constructed packing is used.

If the original packing material has been lost, we recommend that the Measuring Set be packed as follows:

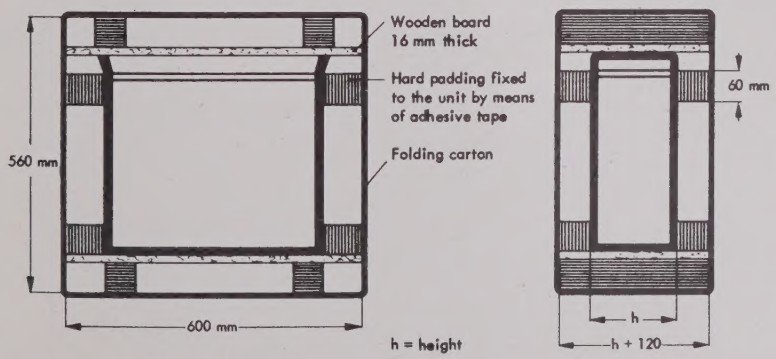

Fig. 5-14 Instructions for packing

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